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PRODUCTION MEASUREMENT OF FUZE COMPONENTS UNDER DYNAMIC STRESS.(U)

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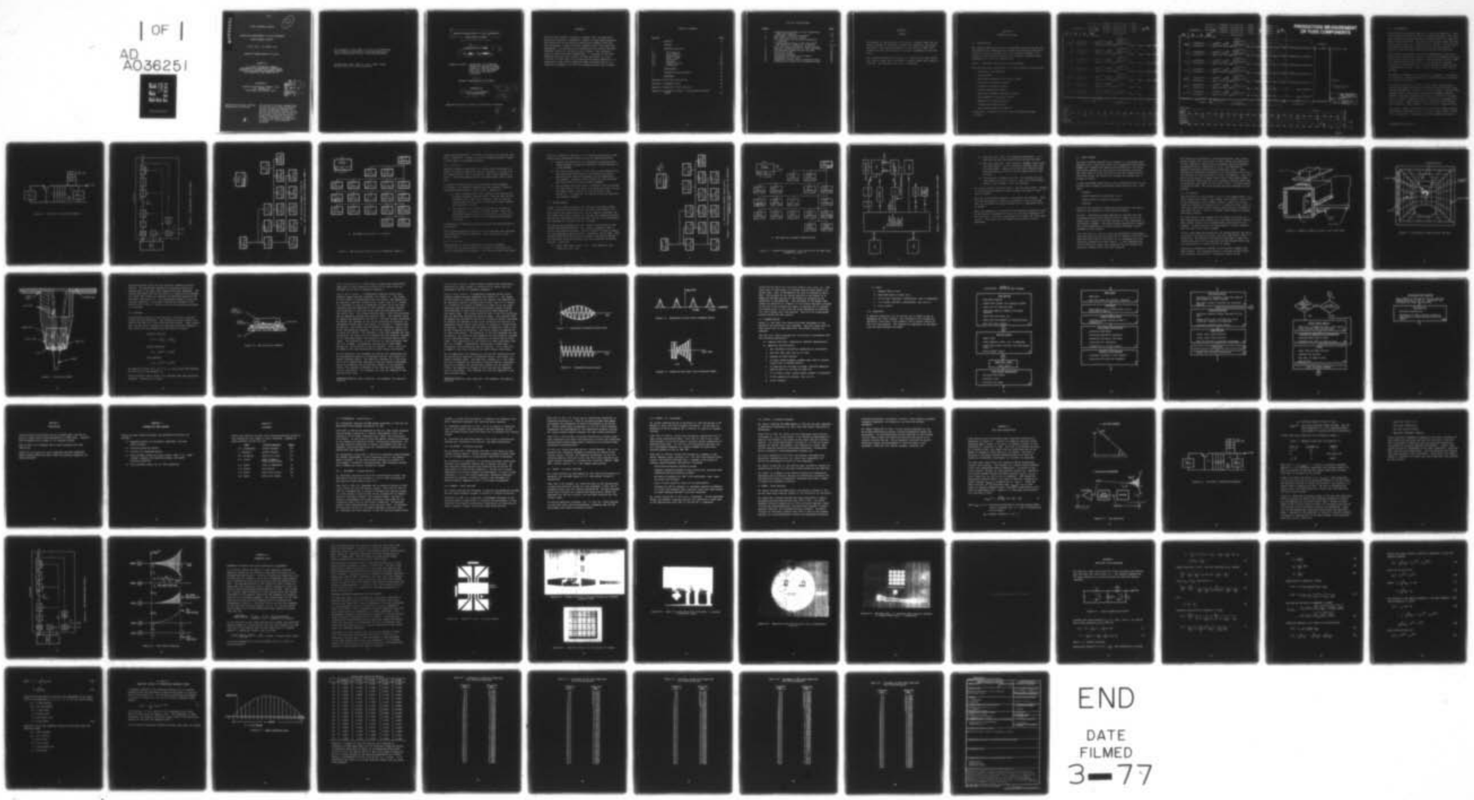

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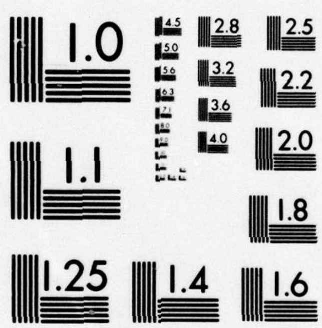

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FIRST QUARTERLY REPORT

PRODUCTION MEASUREMENT OF FUZE COMPONENTS UNDER DYNAMIC STRESS

11 MAY 1976 - 10 AUGUST 1976

CONTRACT NUMBER DAAB07-76-C-0032

PLACED BY

U.S. ARMY ELECTRONICS COMMAND
PROCUREMENT AND PRODUCTION DIRECTORATE
COMMUNICATION SYSTEMS PROCUREMENT BRANCH
FORT MONMOUTH, NEW JERSEY 07703

CONTRACTOR

LOCKHEED ELECTRONICS COMPANY, INC.
U.S. HIGHWAY 22
PLAINFIELD, NEW JERSEY 07061

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This project has been accomplished as part of the US Army Manufacturing and Technology Advance Production Engineering Program, which has as its objective the timely establishment of manufacturing processes, techniques or equipment to insure the efficient production of current or future defense programs.

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PRODUCTION MEASUREMENT OF FUZE COMPONENTS UNDER DYNAMIC STRESS.

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FIRST QUARTERLY REP[redacted]T. no. 1,

11 MAY [redacted] — 10 AUG[redacted]76,

OBJECT OF STUDY: DEVELOPMENT OF A COMPUTER CONTROLLED AUTOMATIC TESTER, CAPABLE OF TESTING AND TRIMMING THICK FILM ADJUSTMENT CIRCUITS AT THE RATE OF 3,000/HOUR

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CONTRACT NUMBER DAAB07-76-C-0032

11 9 Sep 76

PREPARED BY

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ARTHUR J. EISENBERGER
PHILIP KASZERMAN

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ABSTRACT

Work has been started to develop a dynamic test and correction system for electronic assemblies, capable of high speed operation. The system will be verified by testing and trimming 6,000 M732 fuze components (3,000 oscillator assemblies and 3,000 amplifier assemblies). An automatic third generation test station has been designed, which will include a laser trimmer. The following specific tasks have been accomplished: 1) analysis of the fuze components and the test stimuli has been initiated; 2) a top level set of flow charts for the program has been completed; 3) a simulation of the entire system has been initiated; and 4) all electrical components for the fuze assemblies have been released.

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SECTION 1

PURPOSE

The purpose of this program is to develop a dynamic test and correction system for electronic assemblies, capable of high speed operation. The circuits selected for verification under this contract are the oscillator and amplifier assemblies of the M732 Fuze.

The contract requires the delivery of 3,000 units of each assembly, 2900 of which shall have been trimmed to meet their specifications. The required test rate is 3,000/hour.

SECTION 2

NARRATIVE AND DATA

2.1 INTRODUCTION

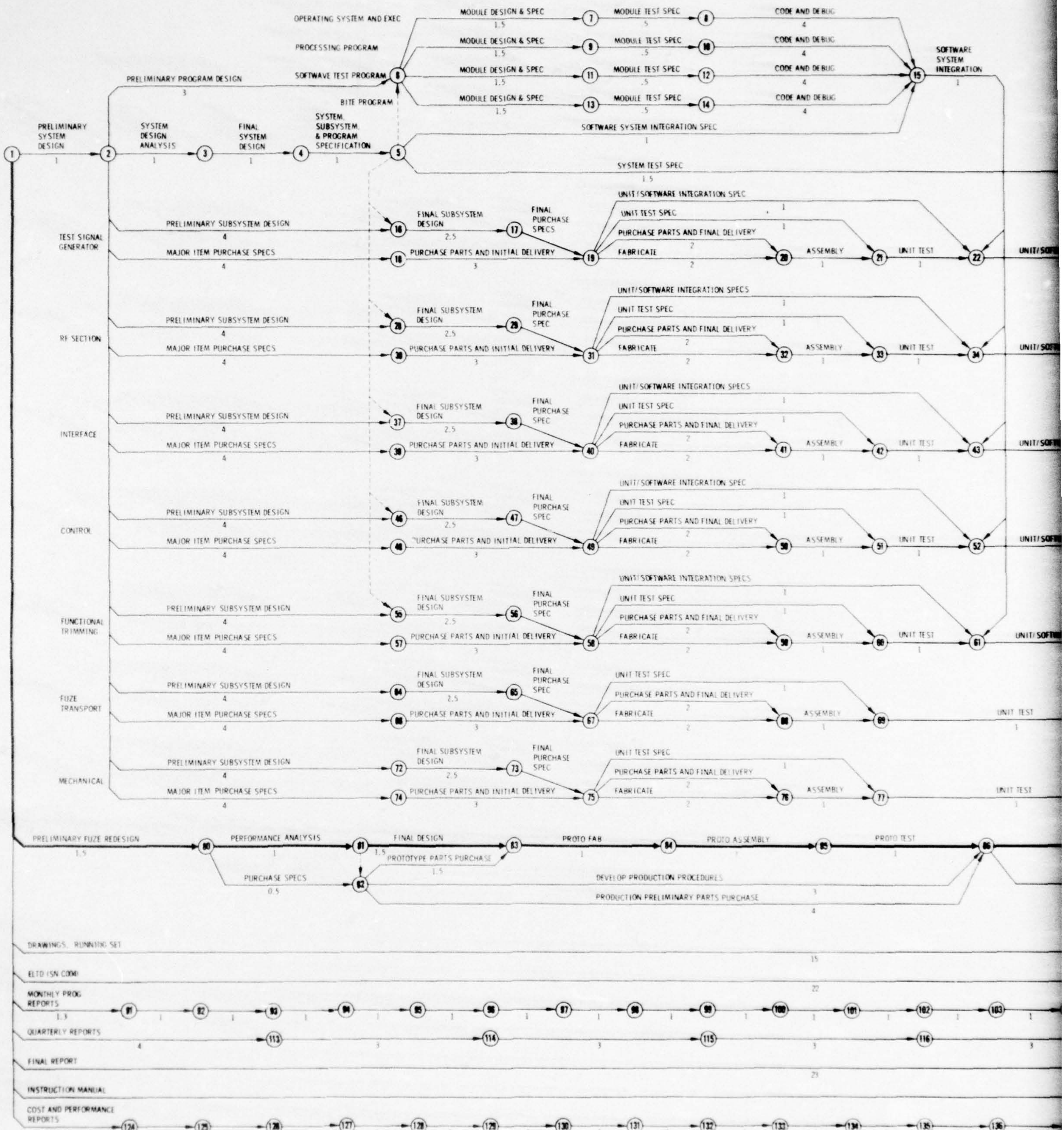
This report summarizes the work accomplished in the first quarter. The contract is a Manufacturing Methods and Technology (MM and T) Program to develop a dynamic test and correction system. The system will be verified by testing and trimming 6,000 M732 fuze components at a rate of 3,000 per hour.

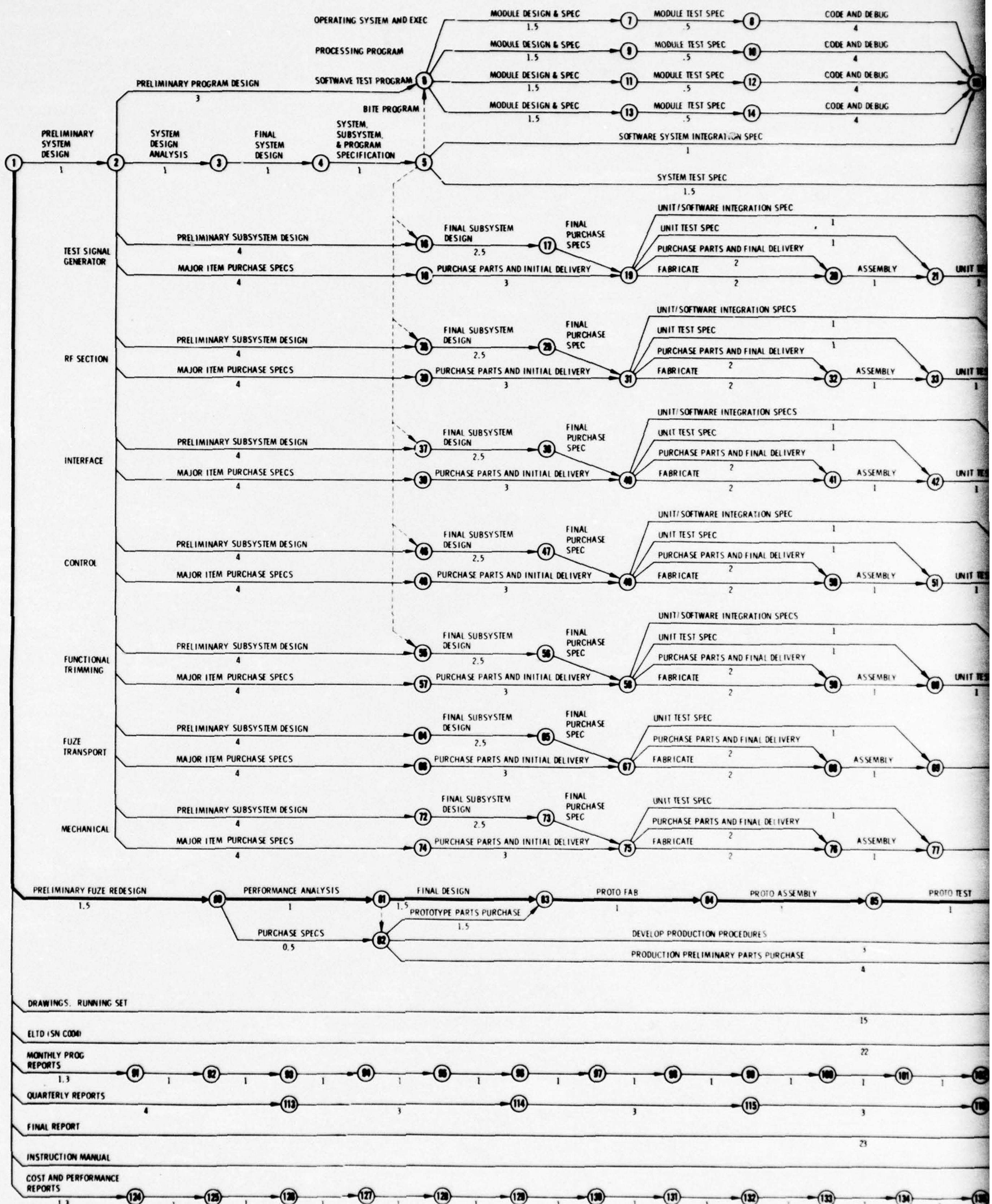
Figure 1 indicates the overall program schedule.

The following major objectives of the first quarter have been met:

- Preliminary Fuze Redesign
- System Design
- Test Signal Generator Preliminary Design
- RF Section Preliminary Design
- Interface Preliminary Design
- Control Preliminary Design
- Functional Trimming Preliminary Design
- Fuze Transport Preliminary Design
- Mechanical Preliminary Design
- Program Preliminary Design
- Test Signal Design 50% Complete

In addition, a simulation of the complete system has been initiated.


OPERATING SYSTEM AND EXEC
PROCESSING PROGRAM
SOFTWAVE TEST PROGRAM
BITE PROGRAM
MODULE DESIGN & SPEC
MODULE TEST SPEC
CODE AND DEBUG
SOFTWARE SYSTEM INTEGRATION
SOFTWARE SYSTEM INTEGRATION SPEC
SYSTEM TEST SPEC
PRELIMINARY PROGRAM DESIGN
PRELIMINARY SYSTEM DESIGN
SYSTEM DESIGN ANALYSIS
FINAL SYSTEM DESIGN
SYSTEM SUBSYSTEM & PROGRAM SPECIFICATION
TEST SIGNAL GENERATOR
RF SECTION
INTERFACE
CONTROL
FUNCTIONAL TRIMMING
FUZE TRANSPORT
MECHANICAL
PRELIMINARY SUBSYSTEM DESIGN
MAJOR ITEM PURCHASE SPECS
FINAL SUBSYSTEM DESIGN
FINAL PURCHASE SPECS
PURCHASE PARTS AND INITIAL DELIVERY
UNIT/SOFTWARE INTEGRATION SPEC
UNIT TEST SPEC
PURCHASE PARTS AND FINAL DELIVERY
FABRICATE
ASSEMBLY
UNIT TEST
PRELIMINARY FUZE REDESIGN
PERFORMANCE ANALYSIS
FINAL DESIGN
PROTO FAB
PROTO ASSEMBLY
PROTO TEST
PURCHASE SPECS
PROTOTYPE PARTS PURCHASE
DEVELOP PRODUCTION PROCEDURES
PRODUCTION PRELIMINARY PARTS PURCHASE
DRAWINGS, RUNNING SET
ELTD ISN C000
MONTHLY PROG REPORTS
QUARTERLY REPORTS
FINAL REPORT
INSTRUCTION MANUAL
COST AND PERFORMANCE REPORTS



OPERATING SYSTEM AND EXEC
PROCESSING PROGRAM
SOFTWAVE TEST PROGRAM
BITE PROGRAM
MODULE DESIGN & SPEC
1.5
MODULE TEST SPEC
.5
CODE AND DEBUG
4
PRELIMINARY PROGRAM DESIGN
3
PRELIMINARY SYSTEM DESIGN
1
SYSTEM DESIGN ANALYSIS
1
FINAL SYSTEM DESIGN
1
SYSTEM, SUBSYSTEM, & PROGRAM SPECIFICATION
1
SOFTWARE SYSTEM INTEGRATION SPEC
1
SYSTEM TEST SPEC
1.5
TEST SIGNAL GENERATOR
RF SECTION
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CONTROL
FUNCTIONAL TRIMMING
FUZE TRANSPORT
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4
MAJOR ITEM PURCHASE SPECS
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FINAL SUBSYSTEM DESIGN
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UNIT/SOFTWARE INTEGRATION SPEC
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PERFORMANCE ANALYSIS
1
FINAL DESIGN
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PROTOTYPE PARTS PURCHASE
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PURCHASE SPECS
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PROTO FAB
1
PROTO ASSEMBLY
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FINAL REPORT
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INSTRUCTION MANUAL
COST AND PERFORMANCE REPORTS
1.3

PRODUCTION MEASUREMENT OF FUZE COMPONENTS

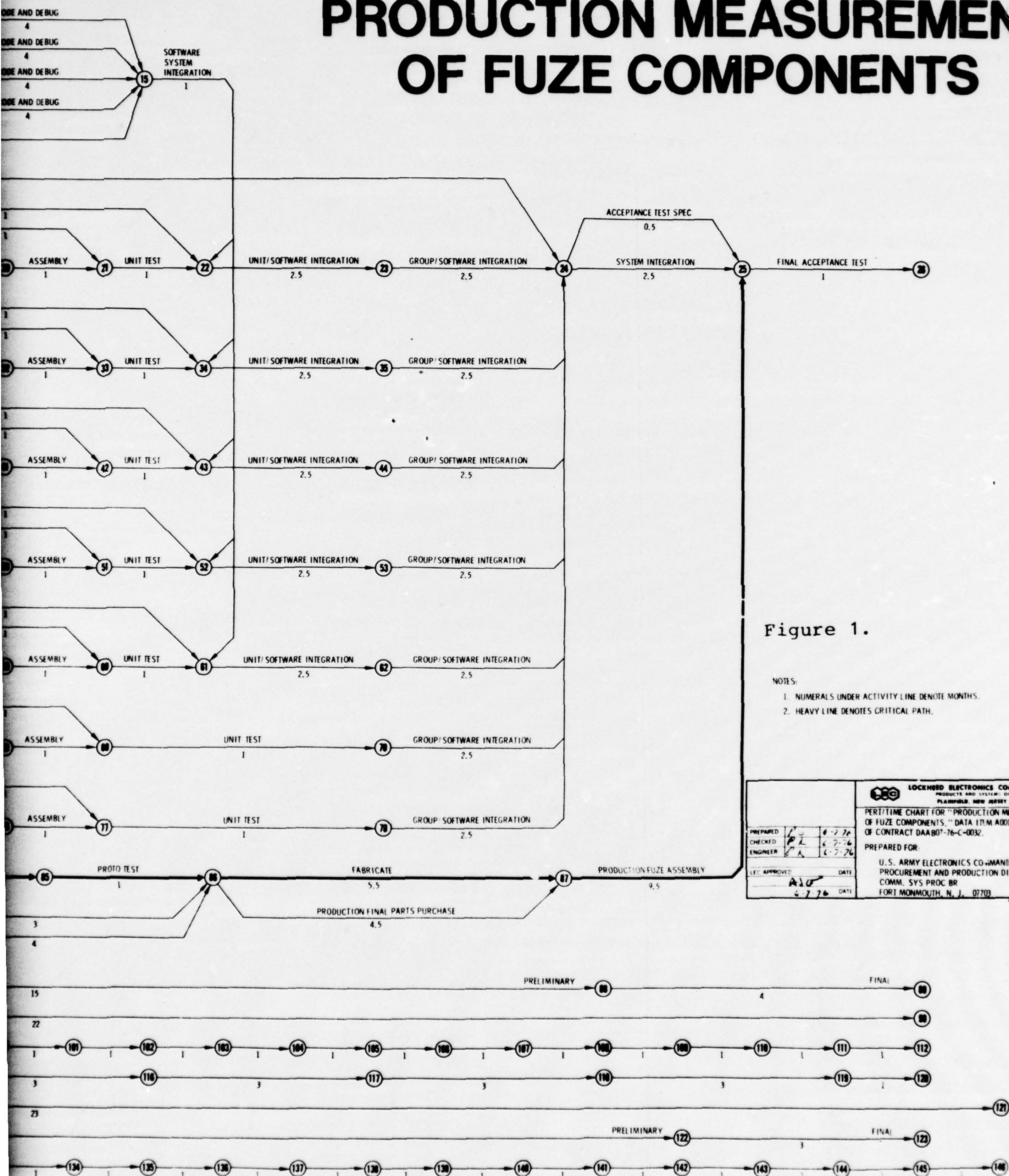

Figure 1.

NOTES:

1. NUMERALS UNDER ACTIVITY LINE DENOTE MONTHS.
2. HEAVY LINE DENOTES CRITICAL PATH.

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ENGINEER		6-7-76
LEC APPROVED	AJG	DATE 6-7-76

LOCKHEED ELECTRONICS COMPANY, INC.
PRODUCTS AND SYSTEMS DIVISION
PLAINFIELD, NEW JERSEY 07061

PERT/TIME CHART FOR "PRODUCTION MEASUREMENT OF FUZE COMPONENTS," DATA ITEM A001, CLIN 0002 OF CONTRACT DAAB07-76-C-0032.

PREPARED FOR:

U.S. ARMY ELECTRONICS COMMAND
PROCUREMENT AND PRODUCTION DIRECTORATE
COMM. SYS PROC BR
FORT MONMOUTH, N. J. 07703

FORM LEC 126-1

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2.2 FUZE REDESIGN

A description of the fuze operation is given in Appendix A. Both the oscillator and the amplifier have been redesigned. The oscillator (Figure 2) will be modified by adding thick film capacitor* pads across C23 and C20. By trimming off capacitor pads with the laser, sensitivity (i.e., Doppler output voltage) will be raised or lowered as required. The sensitivity will be adjusted to a value such that the specification will be met after potting.

The amplifier (see Figure 3) has been redesigned by making the lower leg of the resistor divider a thick film trimmable resistor*. Its initial value is low enough so that the Height of Burst (HOB) will be below specification for all variations in component tolerances. The resistor will then be trimmed to raise the HOB to specification value. Both a coarse cut and a fine cut will be made.

The physical redesign of the amplifier is complete. In addition, all electrical components have been released for both the amplifier and the oscillator.

A decision was made to utilize the most recent Harry Diamond Laboratories (HDL) drawings associated with the M732 Fuze, meeting MIL-F-50596A(MU). Figure 4 (A and B) presents a partial M732 assembly family tree showing component and assembly drawings needed to fabricate unpotted oscillators (11718271-Z) and amplifier (11716460-Z) assemblies meeting production requirements for the M732 fuze. These assemblies are ultimately mated, potted, and attached to other subunits, culminating in a completed fuze.

The drawing numbers presented are the latest HDL (Harry Diamond Laboratories) drawings required for high volume automatic insertion of components. The hybrid amplifier assembly utilizes a

*Described in Appendix B.

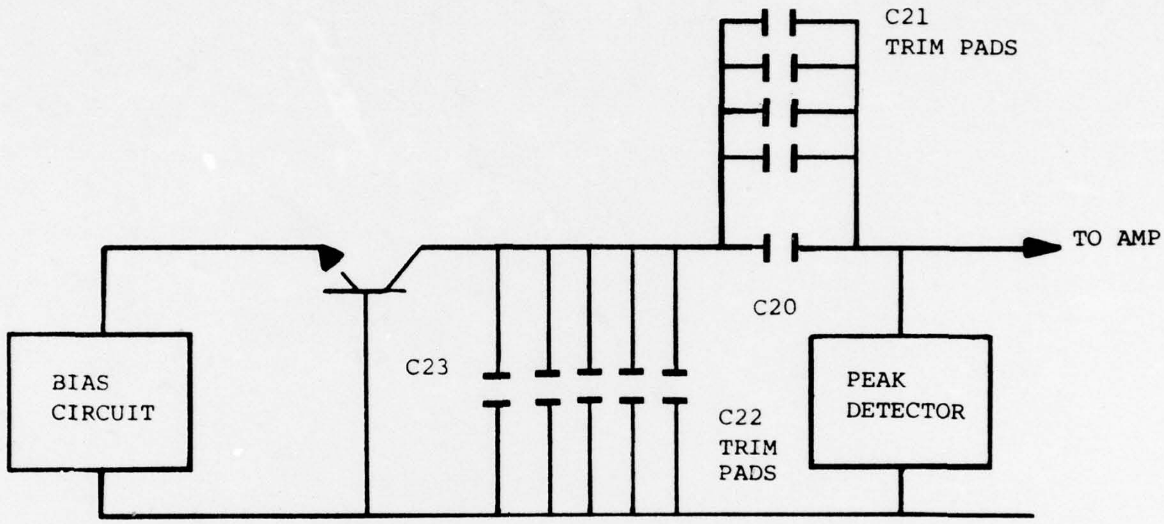


Figure 2. Oscillator, Simplified Schematic

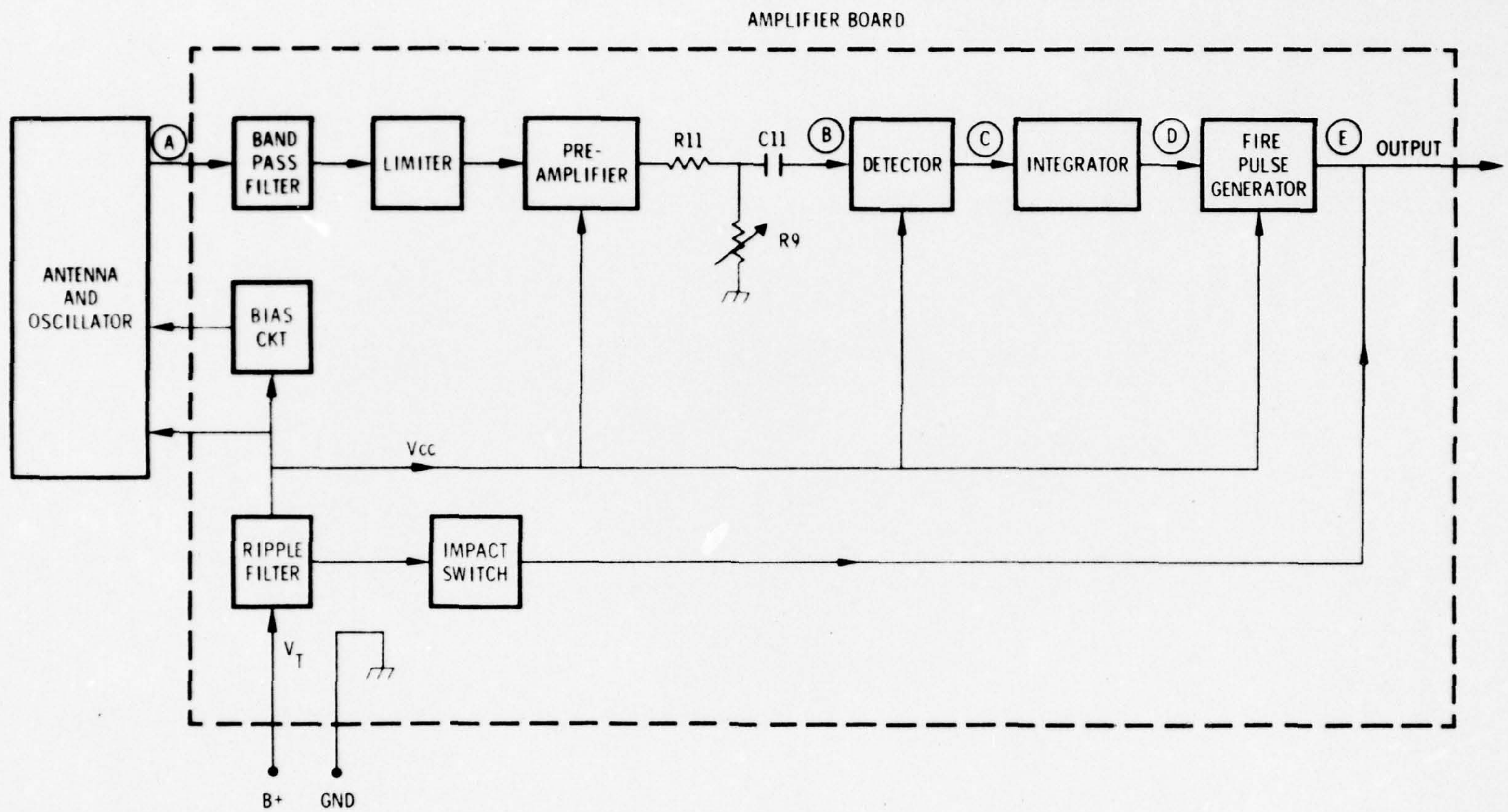
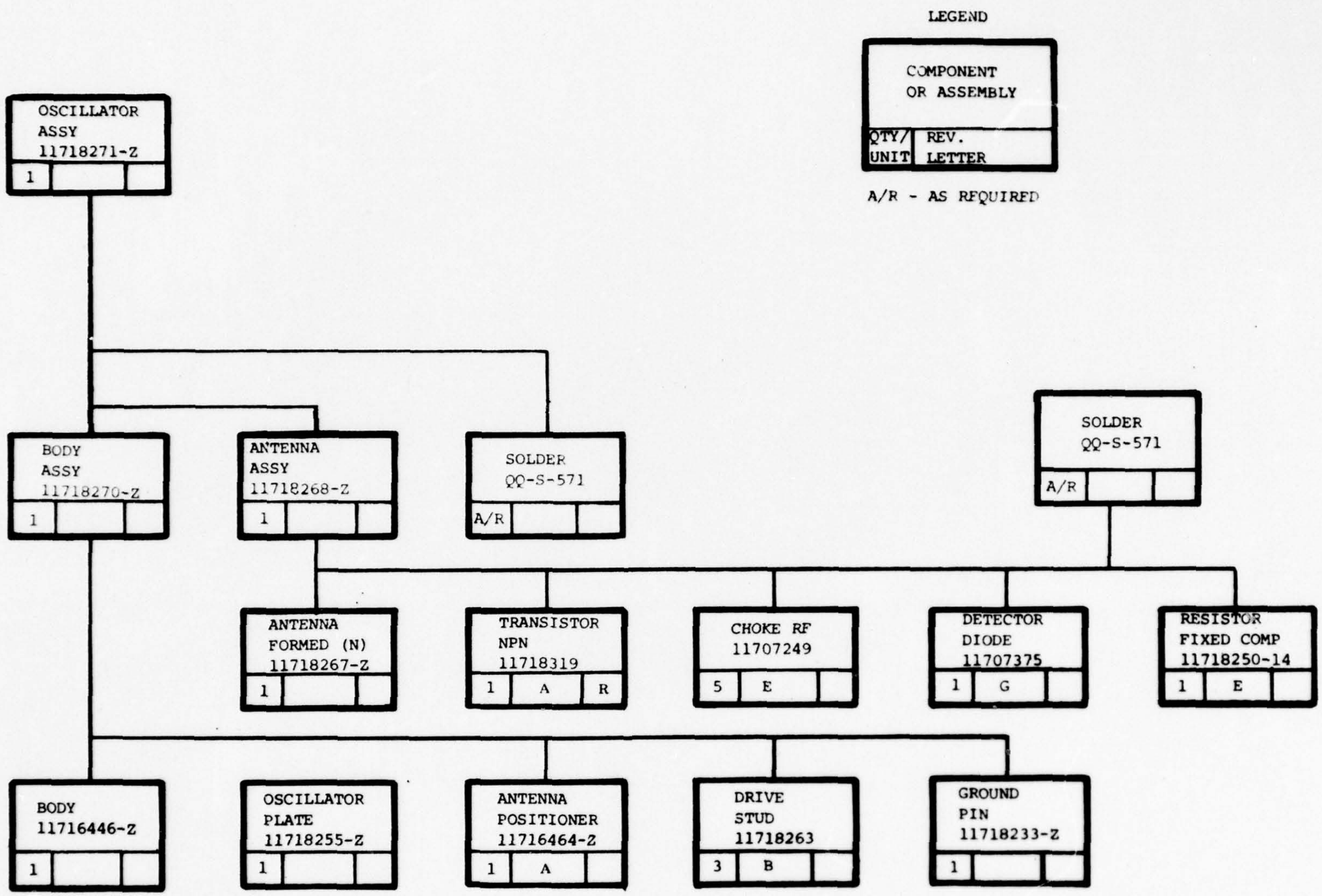
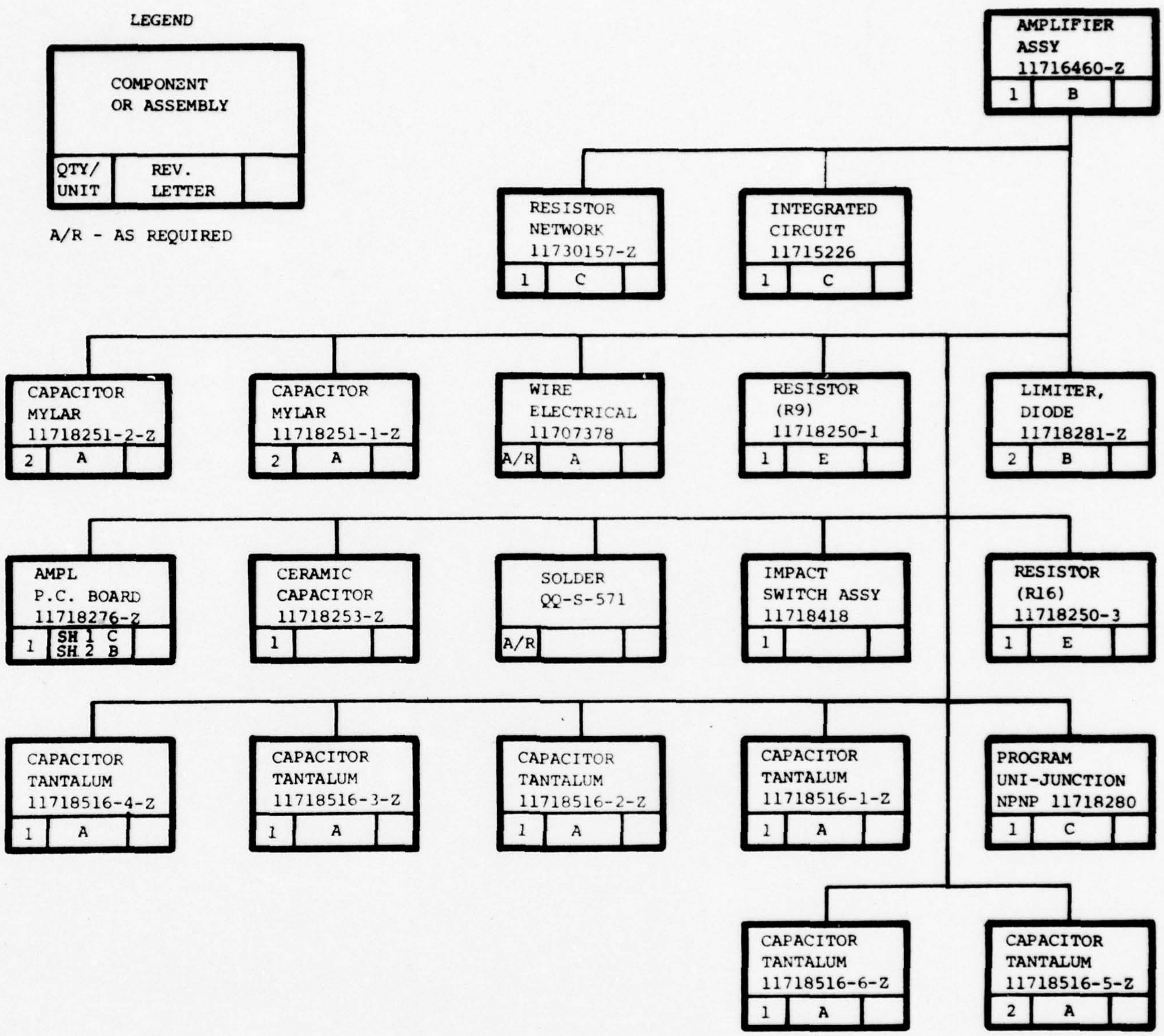


Figure 3. Fuze Amplifier, Block Diagram



A. HDL Oscillator Assembly (11718271-Z)

Figure 4. HDL Oscillator and Amplifier Assemblies (Sheet 1)



B. HDL Amplifier Assembly (11716460-Z)

Figure 4. HDL Oscillator and Amplifier Assemblies (Sheet 2)

single multi-function IC (11715226) and thick film resistor network (11730157-Z). Figure 5 (A and B) presents similar "trees" as they apply to the present program.

2.2.1 *Amplifier*

The M732 production amplifier is a hybrid unit consisting of a number of machine insertable discrete components, a thick film DIP resistor board with 16 resistors, plus a multi-function 14-pin IC. Figure 4B summarizes the component parts list of this unit.

A minimum of modifications to the amplifier board assembly (11716460-Z) are needed to demonstrate the automatic trimming techniques associated with this program. These are:

a) A laser trimmable thick film resistor will replace the existing discrete component (R9). The new unit will be mounted on the under (non-component) side of the production amplifier PC board to facilitate laser trimming and electrical access.

b) The production unit impact switch will be deleted for this program. It should be noted, however, that this additional component could be inserted at a later date as the amplifier PC board is an unmodified HDL production unit.

A comparison of Figures 4B and 5B indicates the modifications to this board.

The delivered prototype amplifier can be completed and installed into fuzes for firing, if desired. This is not part of the present effort.

2.2.2 *Oscillator*

Modifications to the HDL production oscillator assembly (11718271-Z) are more extensive and geared to minimizing the cost of fabrication and assembly. Note that the basic oscillator

electrical design is identical to the existing production units. The principal mechanical modifications are summarized below.

a) Testing and tuning will be performed on unpotted oscillators mounted on specially designed fixtures mounted in a load chamber.

b) The tuning capacitors, C21 and C22, will be deleted from the antenna PC board pattern and replaced by ceramic parallel plate capacitors mounted to the underside of the antenna. Access to these "chips" will be available from the bottom of the new antenna assembly.

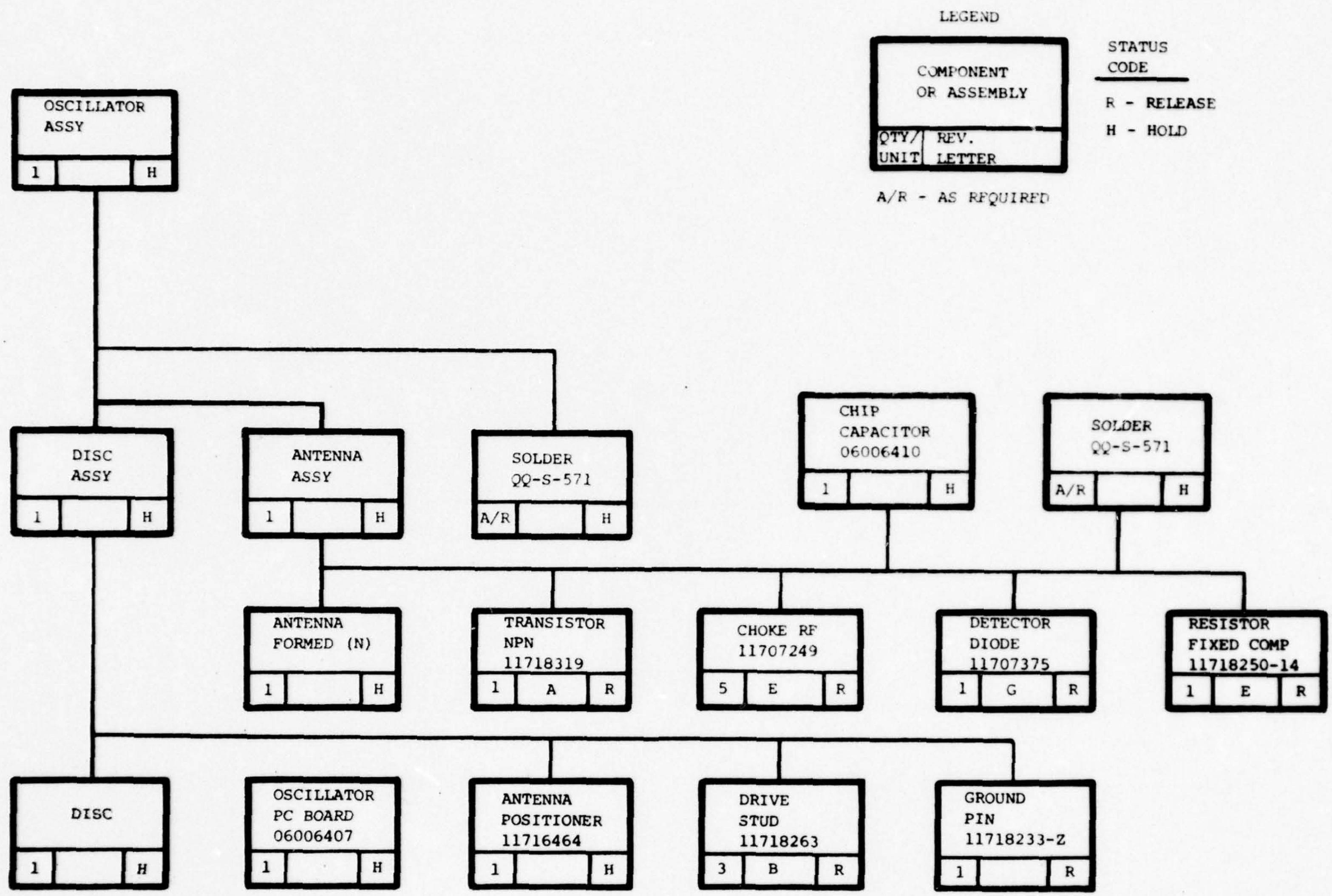
c) The original oscillator body (11716446-Z) will be deleted and replaced by a thin metal disc which will serve as the principal mounting plate for each oscillator (see Figure 10). A comparison of Figures 4A and 5A indicates the expected changes.

2.3 SYSTEM DESIGN

Figure 6 is a block diagram of the test and correction system. It is a flexible third generation automatic test system; i.e., test stimuli are generated by the use of computer programs, the Unit Under Test (UUT) response is sampled, the characteristics of the UUT are calculated by the computer, and the trim requirements and commands are calculated by the computer.

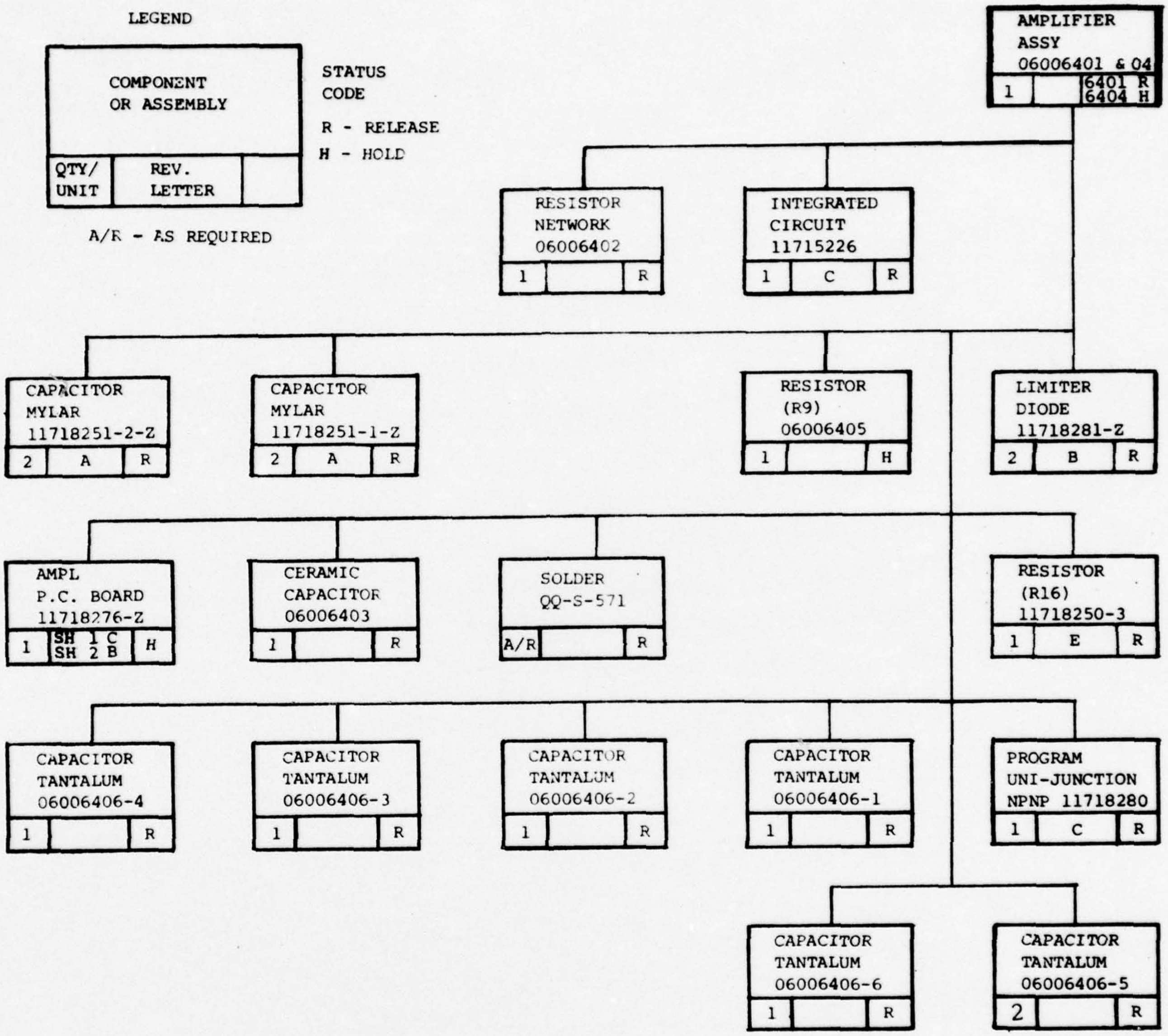
The system was discussed with two computer manufacturers, Data General and Hewlett-Packard. Data General proposed a NOVA 3 with a disk operating system. Hewlett-Packard is able to supply all the hardware except the filter, modulator, and op amps. They propose their 9603A Scientific Measurement and Control System. Four possible operating systems were also suggested by Hewlett-Packard. These are:

a) Paper Tape System using a TTY. This system is very simple but very slow.



A. HDL Oscillator Assembly Modifications

Figure 5. Program Modifications to HDL Oscillator and Amplifier Assemblies (Sheet 1)



B. HDL Amplifier Assembly Modifications

Figure 5. Program Modifications to HDL Oscillator and Amplifier Assemblies (Sheet 2)

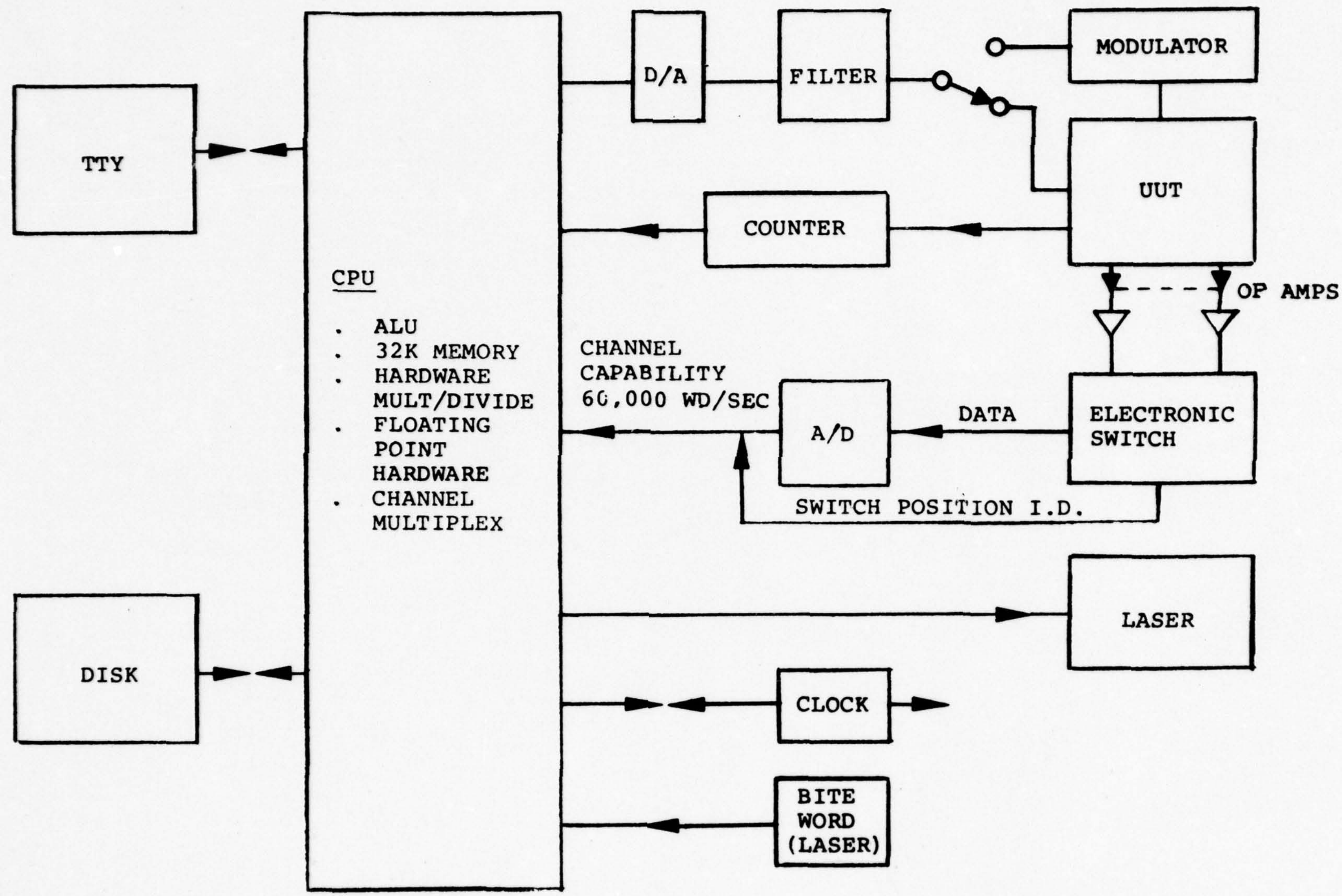


Figure 6. Test and Correction System, Block Digram

b) Disk plus TTY. This is a commonly used system. It is fast and the disk has adequate mass storage for data.

c) Reel tape plus TTY. This system is somewhat slower than the disk system. It has occasional problems with tapes and read heads. Tapes provide the least expensive mass storage medium, but this is not of importance for this contract.

d) "Intelligent" terminal plus TTY. This system has hard copy capability (TTY), magnetic tape, and a CRT display. However, the software is not yet complete.

An initial decision has been made to use the disk system. However, if the intelligent terminal system becomes available in time, it will be chosen.

The use of the ATLAS language is required by the contract. This will be implemented by coding the programs in such a way that they can be called by ATLAS statements (i.e., subroutine calls in ATLAS).

While the hardware is a flexible third generation system, it will be specifically programmed to test and trim fuze components for this contract. It can be reprogrammed for almost any other audio circuit. The effort will be commensurate with the circuit complexity.

2.4 LASER TRIMMER

The laser trimming equipment will consist of a purchased laser assembly with a laser table which will accommodate the anechoic chamber for trimming the capacitors and mounting of the slide nest holder assembly for the trimming of amplifier resistors. The laser table is being designed so that the chamber and the slide nest holder can readily be attached and removed with a minimum of effort.

A laser procurement specification was generated and four of the leading laser trimmer manufacturers were invited to bid. They were:

- Teradyne
- Electro Scientific Industries (E.S.I.)
- Korad division of Hadron Corporation
- Quantrad

The first two potential vendors were eliminated in the early stages of the program for the following reasons:

Teradyne - The optical system designed to function with the galvanometer-mirror beam position did not adapt well to the longer focal length of the beam required to trim capacitors in the anechoic chamber. The modifications required for trimming and visual observation would have imposed formidable design problems on both parties.

Electro-Scientific Industries was non-responsive on the basis that they would not divorce their PDP 11 computer from the laser/ beam positioner section and would not be responsible for any interface problems that might result. It also appeared that their fixed focal length was inadequate for our purposes and extensive redesign would have been required.

The remaining two candidates, Korad and Quantrad, were investigated in depth with field trips to their plants and observation of their systems in production environments (Korad at Anaconda Telecommunications, Garden Grove, Calif., and Quantrad at Chrysler Automotive Electronics at Huntsville, Ala.). Both systems were technically comparable, but the Quantrad unit could more readily be interfaced with a 16-bit minicomputer. Also, the servo motors came up to speed faster than in the Korad trimmer. The Korad KRT 75090 required a D/A converter interface which had a significant cost impact on the overall price. For this reason, the Quantrad Model 1021 Laser Trimmer has been selected for this program.

2.5 RF SECTION

The oscillator will be mounted in an r-f load chamber while it is being tested and trimmed. The chamber (see Figures 7 and 8) will be an aluminum box like chamber of about 1 cubic foot volume, lined with Emerson and Cuming N2-51 r-f absorbing tiles, with an oscillator positioner holder fixture (see Figure 9) attached to the inner top wall. This is a minimum volume needed to produce meaningful results.

The front panel of the chamber will be hinged to function as a door through which the operator will load the oscillator fixture. When closed, the door will automatically latch itself to the chamber. A safety switch will be provided to inhibit operation when the door is not fully latched.

Initial laser beam positioning will be accomplished by the use of a joystick controller which will move the laser beam in the X & Y directions. The operator will position the beam to match the "positioning mark" on the capacitor and the resistor while viewing the results on a closed circuit TV screen.

Preliminary engineering sketches of the anechoic chamber have been started. The absorbing material (sintered ferrite tiles) was purchased and received. Preliminary layout of the

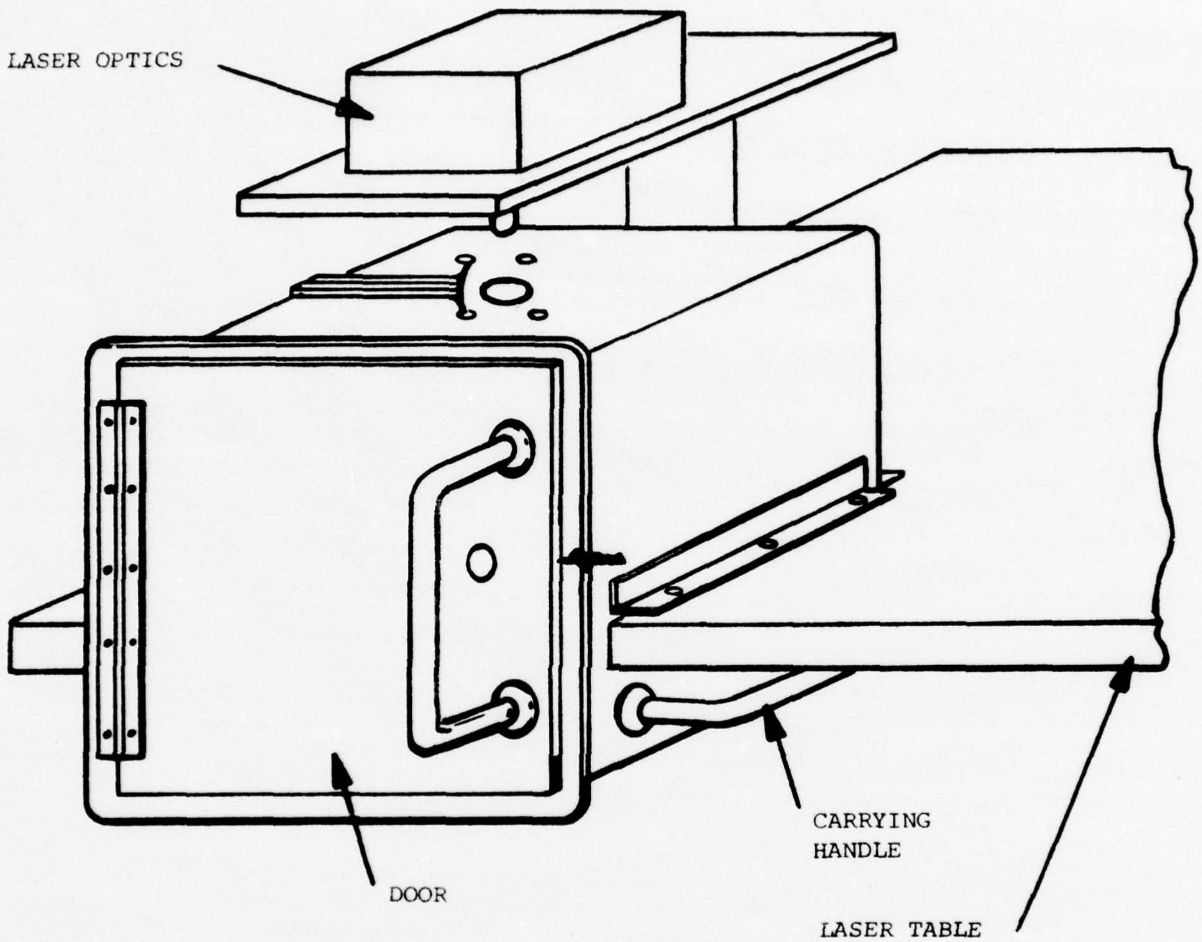


Figure 7. Anechoic Chamber Mounted in the Laser Table

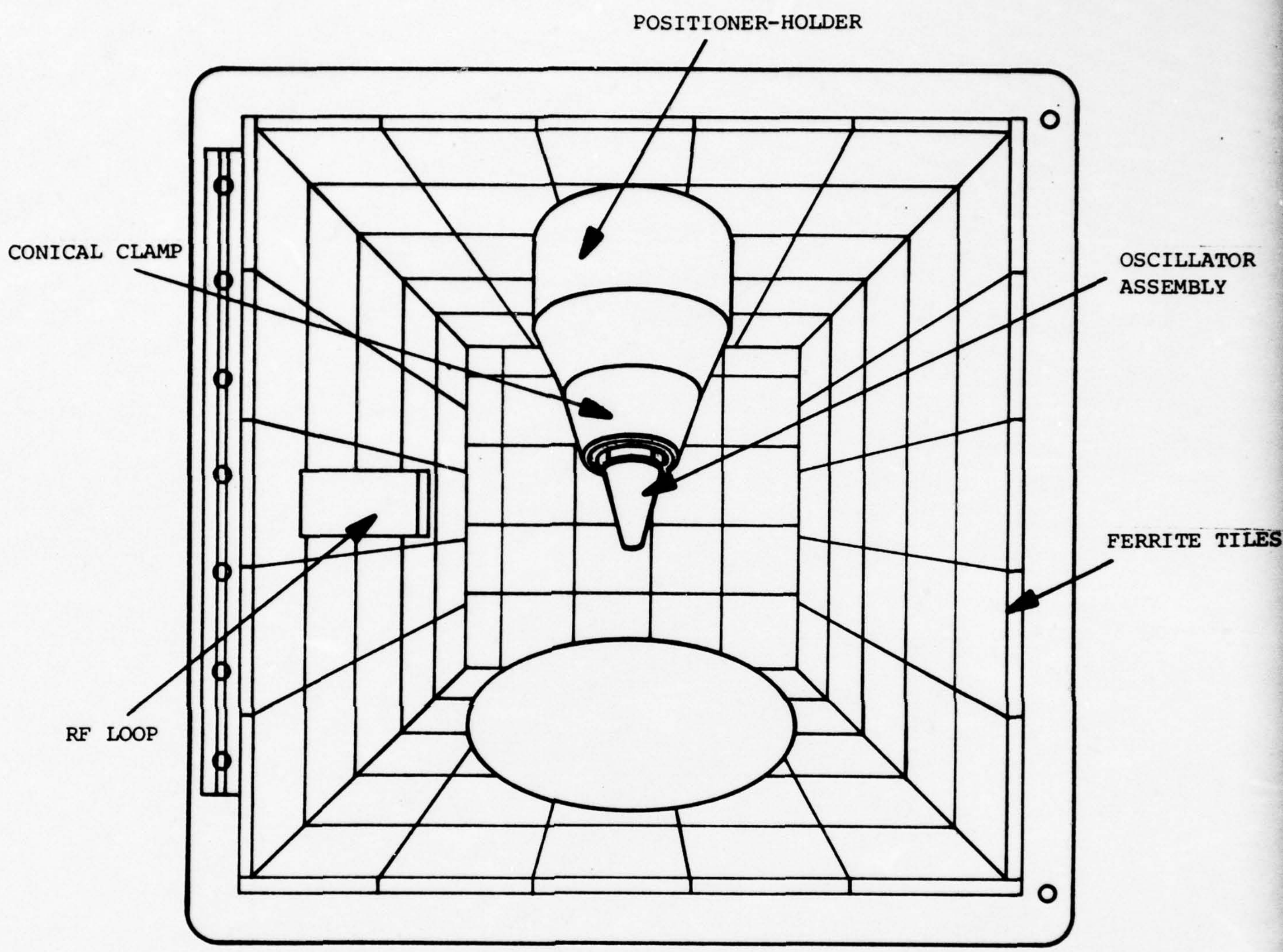


Figure 8. The Anechoic Chamber Without the Door

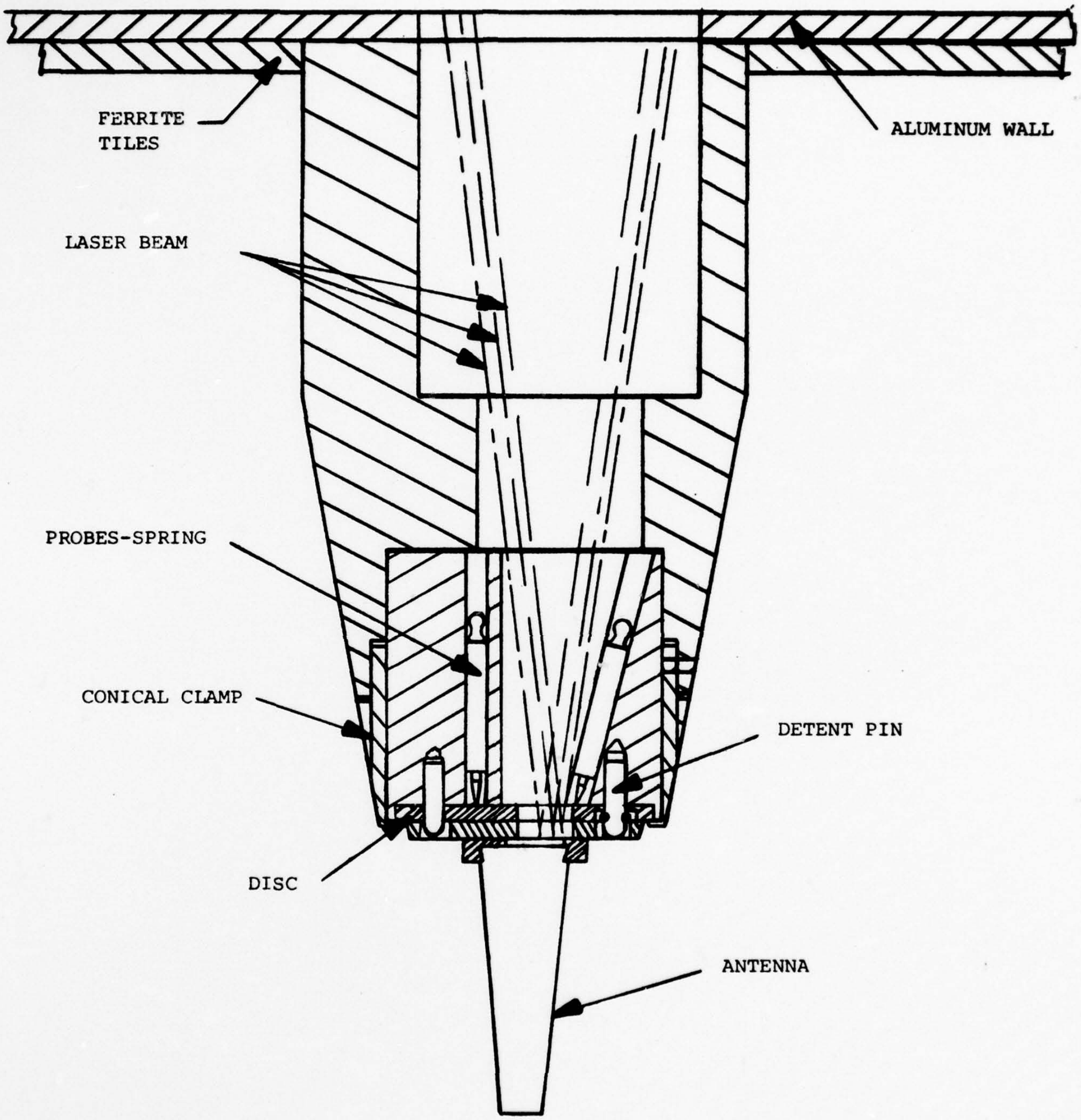


Figure 9. Positioner Holder

positioner-holder device for the amplifier assembly has been started. The preliminary mechanical engineering design for modification of the oscillator assembly has been completed. The antenna positioner and the oscillator P.C. board will be mounted on a steel disc which will simulate the mounting surface of the fuze body (see Figure 10). The engineering sketch for the disc has been completed. Preliminary engineering sketches of the modification of the P.C. board as well as the antenna positioner is in process.

2.6 ANALYSIS

A preliminary analysis of the amplifier, oscillator, and test signals has been performed. The amplifier has two filters; the input filter and the filter following the detector. Both filters have the same form, although the constants are quite different. The filters can be mathematically described as follows:

Transfer function:

$$F(s) = \frac{A}{S + p_1} + \frac{B}{S + p_2}$$

Impulse Response:

$$h(t) = Ae^{-p_1 t} + Be^{-p_2 t}$$

Step Response:

$$g(t) = Ce^{-p_1 t} + De^{-p_2 t}$$

The specific values for A, B, C, D, p_1, and p_2 have been derived for each filter (see Appendix C).

Three different signal stimuli and responses have been partially analyzed. These are as follows:

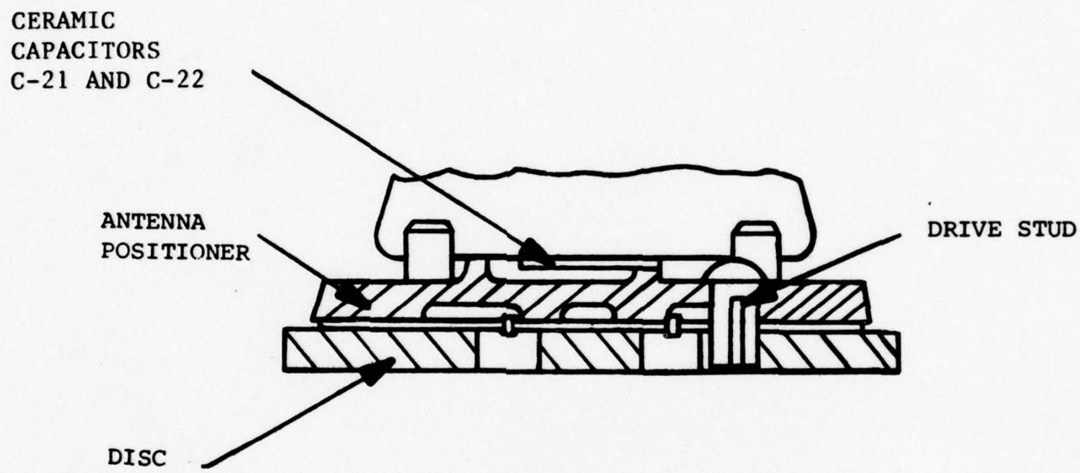


Figure 10. New Oscillator Assembly

Pulse Stimuli Signals - Pulse stimuli signals were rejected because most of their energy is centered at dc rather than the mid-band of the unit's frequency response.*

Carrier Burst Signals - A Tchebycheff weighted carrier burst stimulus signal has been examined (see Figure 11). The energy of this signal is concentrated near the carrier (see Appendix D). By choosing a specific weighting and a burst time of 0.1 second, it is possible to achieve a bandwidth of about 40 Hz and simultaneously keep the magnitude of the frequency content outside this bandwidth to less than 40 dB below the peak magnitude of the center lobe. This signal would be used to test the oscillator and the amplifier through the detector stage. The response would be sampled and analyzed by the use of a Discrete Fourier Transform. To analyze the response of the filter following the detector, an unweighted carrier burst (see Figure 12) lasting 0.1 second would be applied. This would have the effect of applying a step to the filter following the detector. The filter output is sampled for at least four points. The constants in the step response are then calculated. By using the step response and the frequency response of the preceding stages, the response to an M-wave may be calculated. The required cut in the resistor is then calculated, and the unit trimmed. Intermediate calculations of dead space, saturation, and nonlinearity may be required. If so, they will be added to the trim calculation as table lookup corrections.

For the amplifier, the response at high and low frequencies will be determined by applying a suppressed carrier (see Figure 13), double sideband signal. The amplifier response up to the detector will be sampled and analyzed by Discrete Fourier Transforms. Using this analysis and the previous analysis of the detector filter, the response to M-waves at the high and low frequency will be calculated. This response will then be compared to the specification value.

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*Reference Data for Radio Engineers, ITT Handbook, 5th Edition, pp 42-45.

Pulse Stimuli Signals - Pulse stimuli signals were rejected because most of their energy is centered at dc rather than the mid-band of the unit's frequency response.*

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*Reference Data for Radio Engineers, ITT Handbook, 5th Edition, pp 42-45.

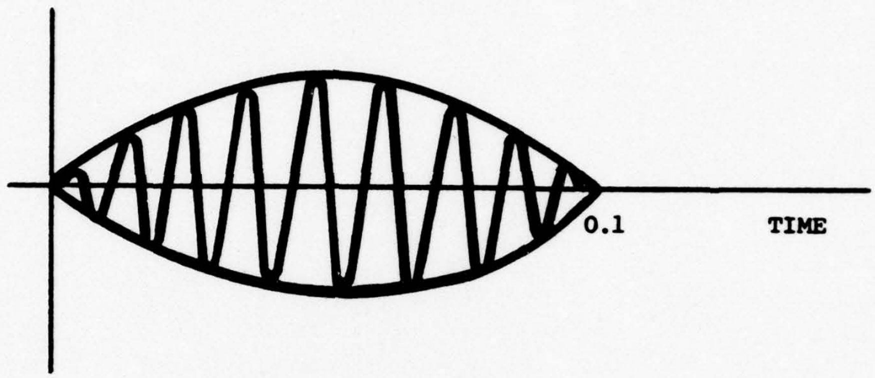


Figure 11. Tchebycheff Weighted Carrier Burst

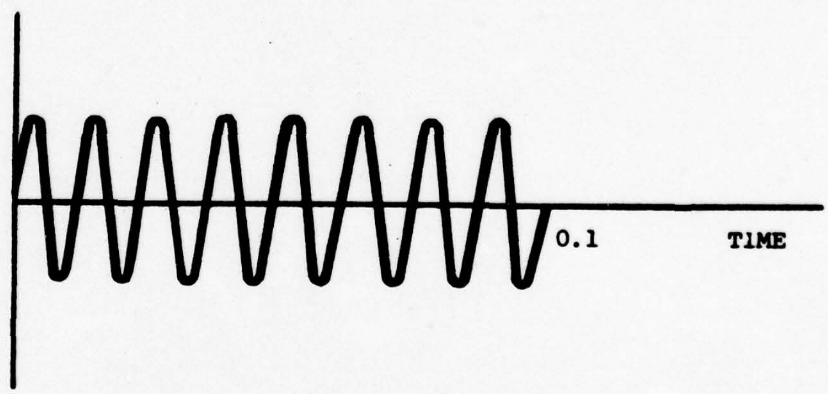


Figure 12. Unweighted Carrier Burst

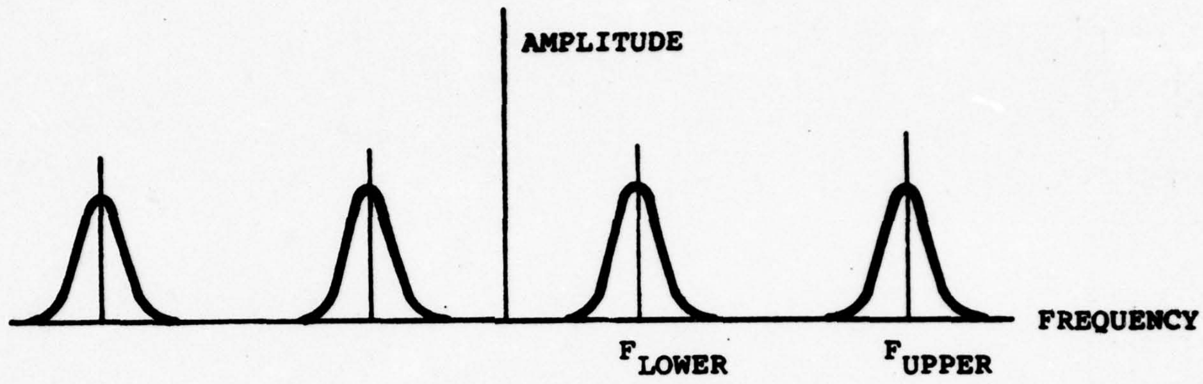


Figure 13. Suppressed Carrier Double Sideband Signal

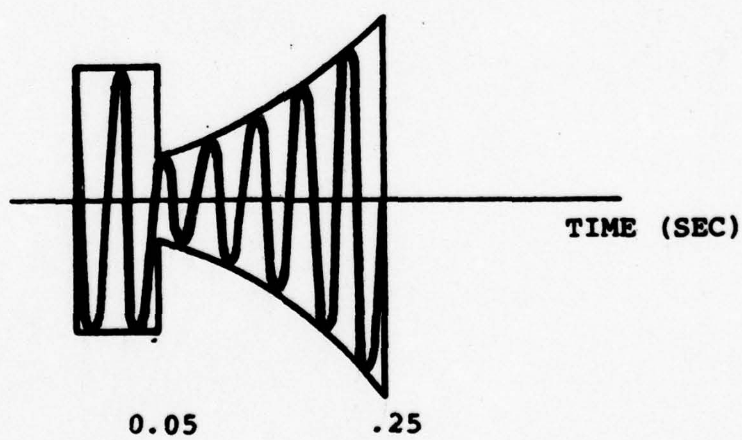


Figure 14. Pulsed Carrier Burst Plus Truncated M.Wave

Pulsed Carrier Burst Plus Truncated M-Wave (see Figure 14) - The front part of this signal is a pulsed carrier burst about 0.05 second long. This is followed by the last 0.2 second of the M-wave. The purpose of the initial portion of the signal is to summarize the past history of the M-wave by charging up the capacitors in the amplifier. The remainder of the signal then causes the amplifier to respond as if an M-wave had been inserted. If the use of this signal can result in meeting the 0.5 percent trim design goal, it will have the great advantage of resulting in a fast running real time program. This will be investigated further during the next quarter.

2.7 PROGRAM DESIGN

Figure 15, top level flow charts have been developed for the amplifier and oscillator test programs. The next lower level of flow charts will be developed after the stimuli analysis is complete.

The self test (BITE) programs will be written in accordance with the following description.

a) Computer Self-Test (supplied by computer manufacturer).

b) Amplifier and Oscillator.

1. Use "standard" electronics (amplifier or oscillator).
2. Run real time test, but do *not* trim.
3. Compare to known answers.
4. If wrong answers appear, compare data read to correct stored data in further detail.
5. If some but not all data is wrong, identify defective path by path I.D. or lack of such I.D.
6. If all data is bad, output signal channel is defective.
7. If all answers are correct, unit is O.K.
8. Print findings.

c) Laser

1. Command laser to cut.
2. Read BITE words in laser unit.
3. If any word indicates a malfunction, unit is defective.
4. If no words indicate a malfunction, unit is O.K.
5. Print results.

2.8 SIMULATION

A complete simulation will be carried out in order to aid in debugging the final program. The simulation will include the amplifier, oscillator, test hardware, and a Fortran version of the real time program. The program for simulation of the amplifier has been designed and coded.

FIGURE 15
FLOW CHARTS - AMPLIFIER TEST PROGRAM

Test Set-Up

- Load Test Program
- Output Test Signal into External Buffer
- Input via TTY Time and Date
- Input any special comments (50 words allowed)
- Input next UUT Serial No.
- Load and print Summary of Previous Tests
- Wait for Start Command

1

A

Initialization

- Reset Clock
- Clear Buffers, Flags, etc. as Required
- Input Laser Start Position (use TTY manual entry)
- Print "Ready" signal

2

B

Read Freq. Meter

(Osc. Only)

Test Signal Application

- Activate Test Signal
- Activate Clock
- Activate Data Read

3

Data Input

- Read Data
- Wait for clock (or channel) interrupt 4

Data Sort

- Sort data by I.D. (Phantom Sort; do *not* move within memory) 5

Linear Calculations

- Calculate signal content by DFT (3 frequencies) 6

Non-Linear Calculations

- Determine Dead Space
- Calculate Equivalent Threshold
- Determine Saturation From Data
- Calculate Sat. Threshold
- Average Gain in Linear Region 7

Detector Calculations

- Calculate Integrator Time Constant
- Calculate SCR coupling constants

8

HOB Calculations

- Calculate gain changes to meet HOB requirements based on linear results
- Add table lookup to correct for nonlinear effects

9

A

Trim Calculations

- Calculate resistor change required for new gain
- Choose type of cut (Straight for first iteration, Shadow for succeeding)
- Calculate required laser motion

10

Laser Motion

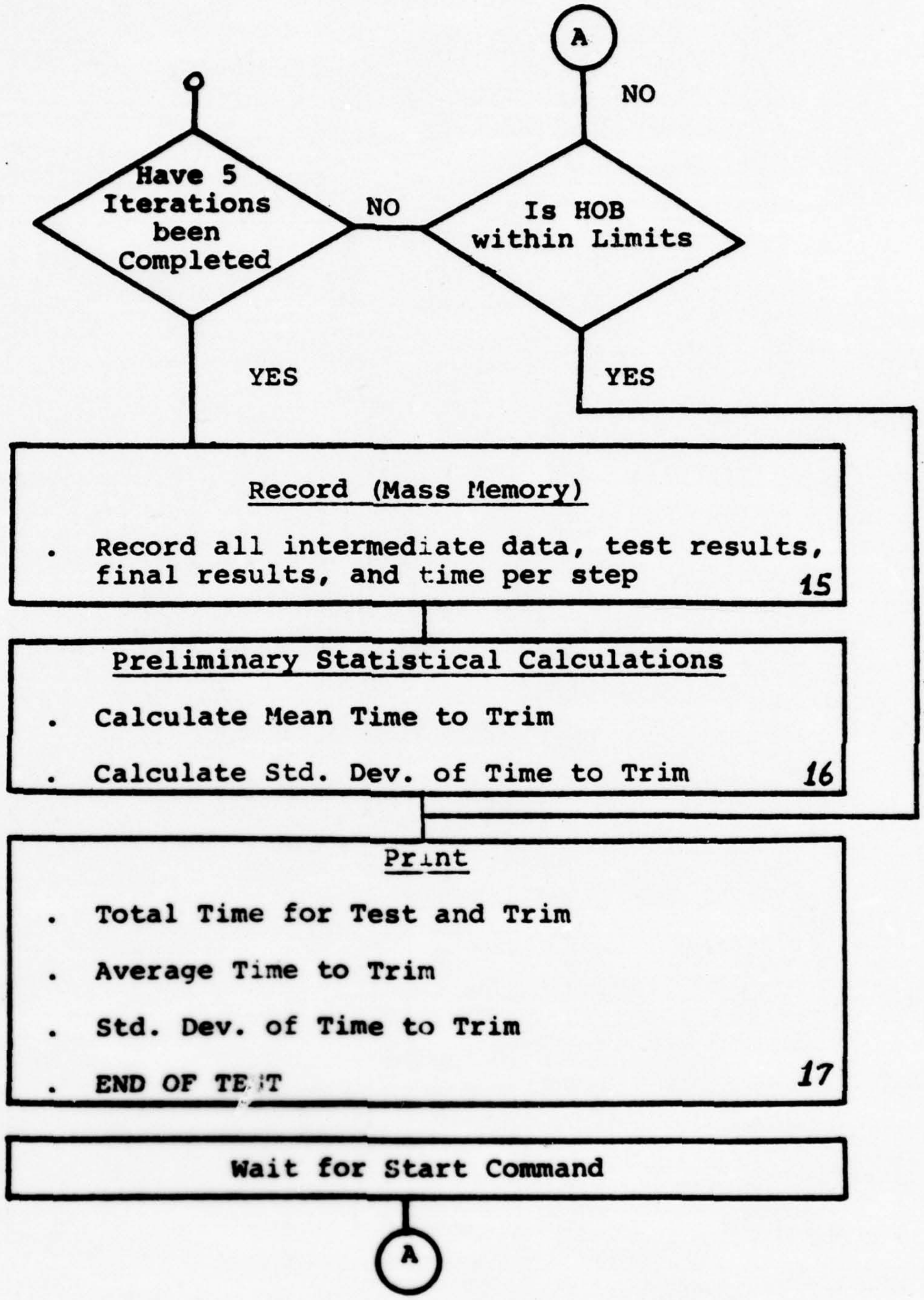
- Output laser start position
- Output laser final position
- Wait for motion to complete (interrupt)

11

Read Clock 12

- Repeat Test and HOB Calculations

13


A
NO
Have 5 Iterations been Completed
NO
Is HOB within Limits
YES
YES
Record (Mass Memory)
. Record all intermediate data, test results, final results, and time per step
15
Preliminary Statistical Calculations
. Calculate Mean Time to Trim
. Calculate Std. Dev. of Time to Trim
16
Print
. Total Time for Test and Trim
. Average Time to Trim
. Std. Dev. of Time to Trim
. END OF TEST
17
Wait for Start Command
A

Oscillator Test Program

This program is the same as for the amplifier except for block 7 thru 10. Substitute the following for these calculations.

Calculations . Calculate sensitivity . Calculate (or table look-up) change in capacitance to bring sensitivity within limits 7-10

SECTION 3

CONCLUSIONS

Program planning and scheduling were accomplished, and the results of these efforts were documented in a PERT Chart. Specific work statements were issued to all cognizant groups.

Work to date is on schedule and no major problems have been identified.

Release of all electrical fuze components has been completed. Tester system design has been firmed and hardware suppliers are being evaluated.

SECTION 4

PROGRAM FOR NEXT QUARTER

During the next reporting period, the following activities are planned:

a) Complete analysis of oscillator, amplifier, and test signal stimuli.

b) Continue simulation effort.

c) Continue all subsystem design.

d) Place purchase orders for major tester items (i.e., laser trimmer, computer and operating system, and tester ancillary hardware)

e) Place purchase orders for all fuze components.

SECTION 5

PERSONNEL

During this reporting period, the following personnel worked on this program for the number of hours indicated. Resumes of these personnel follow the list.

Name	Program Function	Hours
A.J. Eisenberger	Program Manager	158
P. Kaszerman	System Engineer	187
R.F. De Mattos	Tester RF & Fuze	161
H.J. Curnan	Laser Trimmer & Fuze Microcircuits	156
G.L. Freed	Digital Components	34
C.A. Zuroff	Programming	108
U.Z. Escoli	Mechanical Design	188
A.H. Owens	Mechanical Design	43

A.J. EISENBERGER - Program Manager

Mr. Eisenberger received the BEE degree from CUNY in 1949 and the MSEE degree from Rutgers University in 1952.

From 1949 to 1962 he was employed by the U.S. Army Signal Research and Development Laboratory in design, development, test, and evaluation of VT fuzes, communications, radar, and navigational aid jamming. He was Section Chief and Special Technical Assistant in the Jamming and Deception Branch, Surveillance Department. He has had extensive experience in design, development and test of wideband, high power amplifiers and transmitters, modulators and specialized test equipment.

Mr. Eisenberger joined LEC in 1962 and is presently Program Manager for Dynamic Measurement of Fuze Components and all LEC Special Sensor programs. He has been Project Engineer on airborne VT fuze jammers, classified countermeasures, AIMS steerable antenna, and a command and control information system.

DR. P. KASZERMAN - Systems Engineer

Dr. Kaszerman received the BA degree from Brooklyn College, the MEE degree from New York University, and in 1964 the Doctor of Engineering Science degree from N.Y.U.

From 1949 to 1954, Dr. Kaszerman was in charge of design of electronic units for the B-52 control system. From 1954 to 1975 at ITT, Dr. Kaszerman was in charge of hardware and software design of a wide variety of analog and digital systems such as communications, electronic warfare, and tracking ranges. He was in charge of programming the signal processing algorithms for the integrated radio room for the Trident submarine. He designed missile track countermeasures vs Soviet SA-3 radar. He designed the switching center for the AUTEC underwater tracking range. Dr. Kaszerman was Chief Engineer of the ITT FTR East Newark plant,

engaged in design and manufacture of computer for shipborne automatic degaussing equipment and regulated power supplies.

Dr. Kaszerman joined LEC in 1975. He is in charge of system design of the dynamic fuze measurement and test program. He has also performed system study and design for an advanced fire control system.

Dr. Kaszerman has published papers in his field in Aeronautical Engineering, Information and Control, and IEEE Transactions.

R.F. DE MATTOS - Principal Engineer

Mr. De Mattos has a BSEE degree from MIT in 1957 where he also studied optical masers. He has completed graduate courses leading to the MSEE degree at Polytechnical Institute of Brooklyn.

Mr. De Mattos is a specialist in miniature microwave solid state receiver and transmitter design used in fuzing circuitry. He has conducted investigations into modifications of the XM 732 fuze design for high volume production. He has over 18 years experience in electronic design and development (16 years at LEC) including L, S, C, and X-band augmenters, monopulse receivers, microwave DF systems, automatic computer test equipment for Polaris missile components, and S- and X-band transponders.

M.J. CURNAN - Staff Engineer

Mr. Curnan received the BS degree in physics from Manhattan College and has taken graduate courses in physics at Fordham University.

From 1953 to 1967, Mr. Curnan was a Development Engineer at ITT Avionics where he specialized in research and development of thin and thick film hybrid microcircuits, fabrication of tunneling devices, varactor diodes, and various solid state devices.

From 1967 to 1971, Mr. Curnan was an Engineering Supervisor at Lockheed Electronics Co. where he provided process development and support for production of thick film modules on Mk 86 WCS. Mr. Curnan joined Optel Corporation in 1971 as a Staff Engineer responsible for development of low temperature hermetic sealing for liquid crystal digital displays for high volume production.

From 1973 to 1975 at RCA, he studied feasibility of using thick film conductors with thick film resistors on large area substrates and developed etched copper-kapton laminates for microwave power transistor interconnections.

In 1975, Mr. Curnan rejoined LEC as a Staff Engineer. He is responsible for designing automation technique for hybrid microcircuit layout, testing, and automated processing. He has contributed numerous articles on thin and thick film production and hybrid design techniques to professional societies (NEPCON, IEEE, Amer. Ceramic Society, etc.) and company publications.

G.L. FREED - Principal Engineer

Mr. Freed received the BSEE degree in 1962 from the University of Rochester and the MSEE degree in 1971 from Newark College of Engineering.

From 1964 to the present, Mr. Freed has been at LEC specializing in hybird microcircuit design for test equipment, fuzes, and an advanced digital gun fire control system Mk 86. He has developed solid state circuits for airborne ECM applications, MADAR test equipment for the C5A aircraft, and the AGFCR advanced gun fire control radar.

At Electro Mechanical Research, Inc. in 1963, Mr. Freed designed low and high level analog multiplexers, telemetry PDM and PAM multicoders and analog switching circuits.

C.A. ZUROFF - Sr. Programmer

Mr. Zuroff received the BS in EE degree in 1955 and the MS in EE degree in 1959, both from Columbia University. He has been an Assistant in EE at Columbia and a Lecturer in Physics at Adelphi College.

From 1955 to 1960 Mr. Zuroff had progressive responsibilities in data system engineering tasks. From 1960 to 1963 he was a Systems Engineer on the Atlas missile guidance system integration at American Bosch Arma. In 1963 he joined Brookhaven National Lab as a Development Engineer on a Bubble Chamber hi-speed photo analysis system on-line to IBM 7094.

From 1967 to 1974 Mr. Zuroff was employed by a number of companies (Western Union, Dynelec, N.Y. City Off Track Betting Corp., Litton, and Computer Horizons Corp.) engaged in the design of computer system hardware and software including:

- TCCS/Info-Com Message Switching System
- Assembly language programs to test Varian 6201 interface with communications multiplexing hardware.
- QA tests of software for IBM 360/50 processors, disc, tape, and large core storage.
- Point of sale terminals using LSI microprocessors
- Programs for SEL 85 computer to implement operator procedures of a real time merchant ship similator using real time monitor and MACS hardware/software interface subsystem.

Mr. Zuroff joined LEC in 1974 as Sr. Programmer. He has specified design and assembly language programs for reduction of radar data in ATC applications using LEC 16 and DEC PDP 11 computers.

U.Z. ESCOLI - Principal Engineer

Mr. Escoli received the BSME degree in 1950 and the Dipl Ingenieur in Mechanical Engineering in 1952, both from Israel Institute of Technology.

From 1956 to 1962, Mr. Escoli was with Burroughs Corp's Control Instrument Co. as a Group Leader in the design and development of optical card readers, high speed printer punch and mail sorting machine. He joined Mergenthaler Linotype Co. in 1962 as Product Manager for design, development, and production of photo typesetting machines employing high speed mechanisms, intermittent motion transports, electromechanical devices, etc.

At Litton Industries (1971-1973) and General Instrument Corp, Electronic Systems Division, Mr. Escoli was responsible for design and development of point of sale terminals.

Mr. Escoli joined LEC in 1975 and has been involved in design for mechanization of XM 732 fuze high volume production and handling.

Mr. Escoli is a member of the National Society of Professional Engineers and the American Society of Professional Engineers and the American Society of Mechanical Engineers and holds a number of patents for mechanical devices.

A. OWENS - Staff Engineer

Mr. Owens received the BSME degree from Adelphi College in 1947. He has taken post graduate courses at the University of California.

Mr. Owens was a design engineer and group supervisor at Sperry Gyroscope and Arma Engineering from 1948 to 1952. He joined Republic Aviation Corporation in 1952 as Project Engineer, where he directed electromechanical and mechanical programs in weapon systems, missiles, and advanced military hardware. At Philco Division of Ford Motor Company from 1960 to 1963 he was Systems Engineer for electromechanical systems and subsystems employing

microminiaturization, electronic controls, video display recorders, waveguide complexer, A/D computers, and test and checkout equipment.

Mr. Owens joined LEC in 1963. He was Project Engineer for the Mk 86 GFCS modification project involving mechanical design and development. He was Supervisory Project Engineer in the Printed Circuit Section where he supervised planning and design of all printed circuits for LEC. He is presently involved in electro-mechanical design and development of fuze and missile test equipment, radar gun fire control systems, antennas, etc.

APPENDIX A

M732 FUZE DESCRIPTION

Fuze operation may be described under idealized conditions by referring to Figure A-1. Figure A-1a shows an artillery round impinging upon a target at an angle (θ) degrees, height (h) and traveling at a velocity (v) mph. The fuze is activated initially by a timing circuit (not shown) that was previously set by the gunner to actuate at some time prior to impact. The fuze is emitting rf CW energy roughly omnidirectionally so that the ground is illuminated continuously as altitude (h) decreases.

The oscillator (see Figure A-2) serves as the CW transmitter, antenna, and receiver. The receiver is a simple diode connected across the transmitter/antenna combination. A portion of the total transmit voltage (E_t) and receiver voltage (E_r) induced in the antenna appears across the diode terminals ($e_d(t) = E_t(t) + E_r(t)$; where e_d, E_t, and E_r are all phasors). The diodes and associated circuitry serve as a peak rf detector, producing an output voltage ($e_{sens}(t)$) proportional to $|e_d(t)|$. Since the shell velocity (v) is relatively high, $e_{sens}(t)$ is an audio signal at doppler frequency which increases in amplitude as altitude (h) approaches zero. Equation (1) describes this waveform as a function of time.

$$e_{sens}(t) = \frac{E_{max}}{(A - Bt)} \cos (W_d t + \phi_d) \qquad (1)$$

where E_{max}, A, B = Constants determined by the fuze output power, Initial altitude (ho), v, θ and rf reflectivity of the ground.

W_d = doppler frequency = $f(v, \theta)$

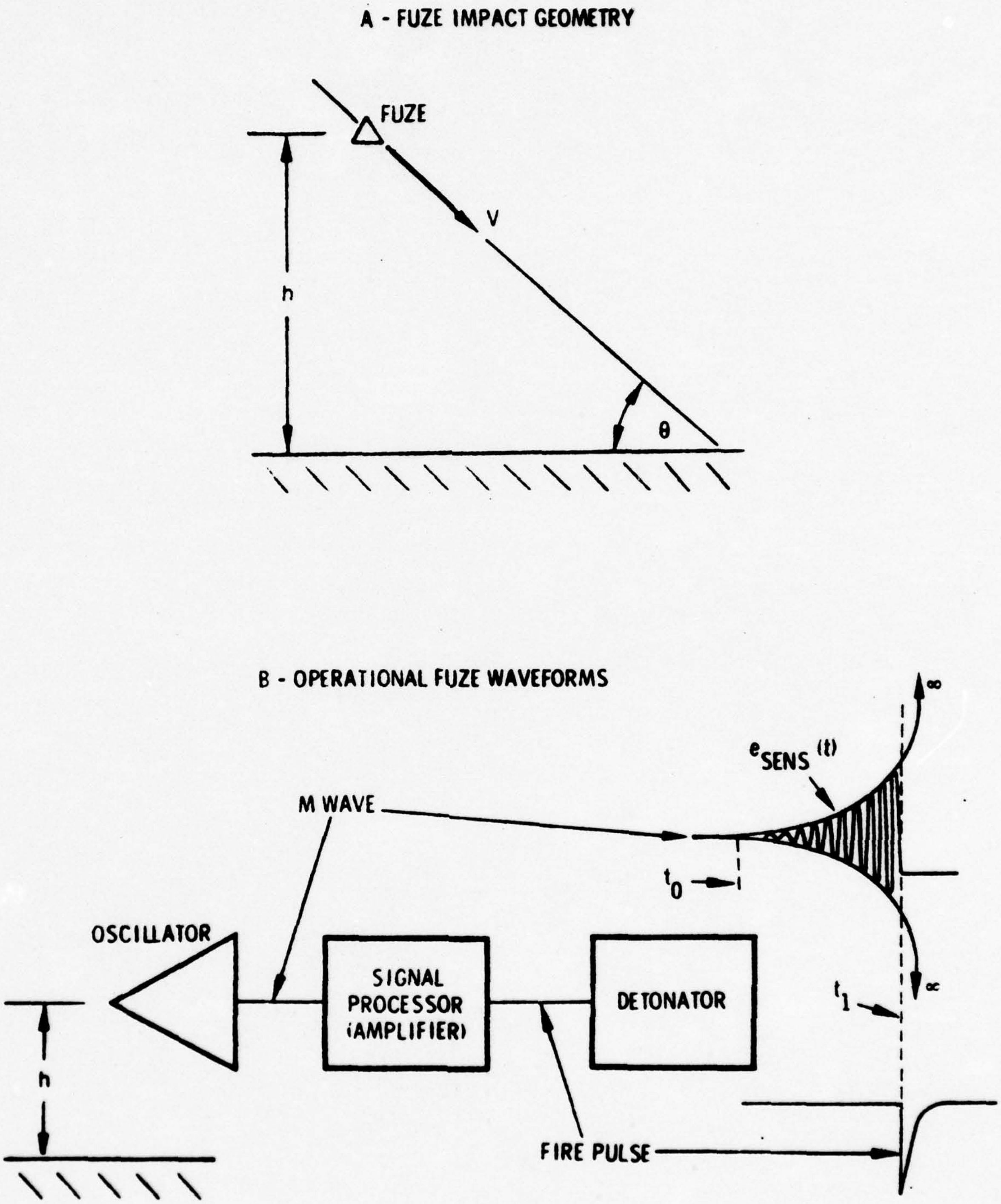


Figure A-1. Fuze Operation

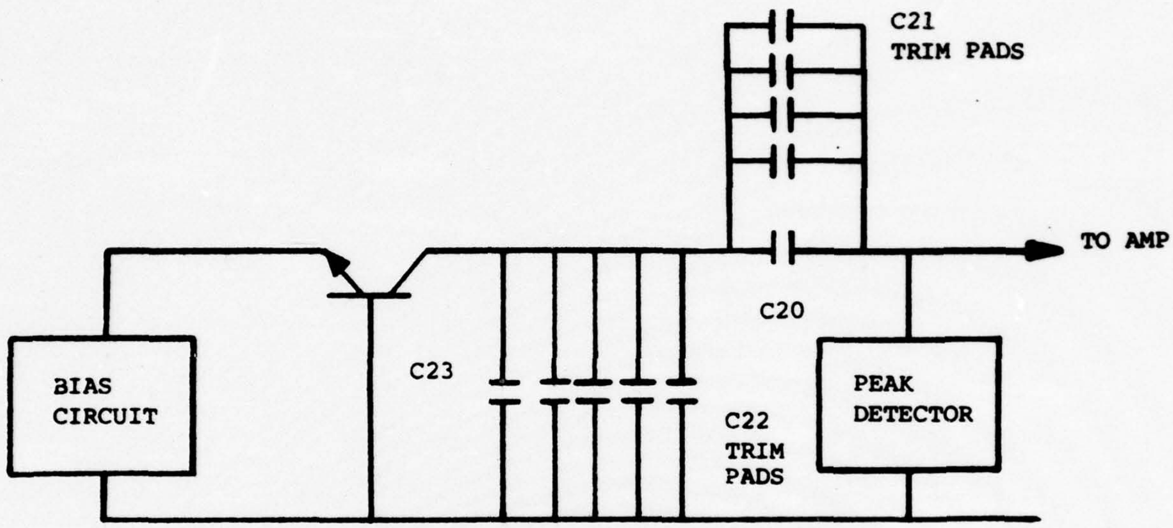


Figure A-2. Oscillator, Simplified Schematic

θ_d = arbitrary phase relative to $E_t(t)$

$e_{sens}(t)$ = oscillator detected output voltage. The rms level expected at h = H ft (desired detonation height) is called oscillator sensitivity.

Initial and final conditions are indicated in Table 1.

Table 1. Boundary Conditions for Equation (1)

Time (t)	Altitude (h)	Comment
$t_0 = 0$	h_0	---
t_1	h_1	fire pulse out
$t_2 = \frac{A}{B}$	0	impact

Note that $t \to t_2$; $e_{sens}(t) \to \infty$, which is obviously incorrect. Equation (1) is, therefore, applicable for distances where $t<t_2$ and is presented to indicate the general amplitude variation with time (or distance to the ground).

Figure A-1B shows the M-wave (i.e., $e_{sens}(t)$) after detection at the oscillator and at the amplifier outputs of the M732 fuze. The amplifier accepts an M-wave and provides a fire pulse at its output after an appropriate time. The time is determined by signal level, oscillator/amplifier overall gain, and amplifier SCR gate firing voltage.

Figure A-3 shows the individual stages of the M732 fuze amplifier. Critical points are labelled and waveforms presented in Figure A-4 corresponding to a typical M-wave input. Height of burst (HOB) is the critical figure of merit in a proximity fuze and is the quantity to be calculated utilizing FFT techniques. Variation in HOB depends upon many quantities within the individual fuzes. Analysis of the waveforms in Figure A-4 and the circuitry of Figure A-3 reveals some of the major causes in HOB variation from fuze to fuze, which are:

- Amplifier overall gain
- Oscillator sensitivity
- SCR gate firing voltage
- Amplifier frequency response

Since relatively inexpensive components with wide tolerances are used within the oscillator and amplifier sections of the M732 fuze, adjustment of amplifier gain and oscillator sensitivity are essential to provide specified performance. Present techniques provide for adjustment of two basic parameters: amplifier HOB, and oscillator sensitivity. Previous amplifier HOB testing used three M-waves in the time domain. These tests are lengthy, making it impossible to attain the 3,000 fuzes/hour rate required by the contract.

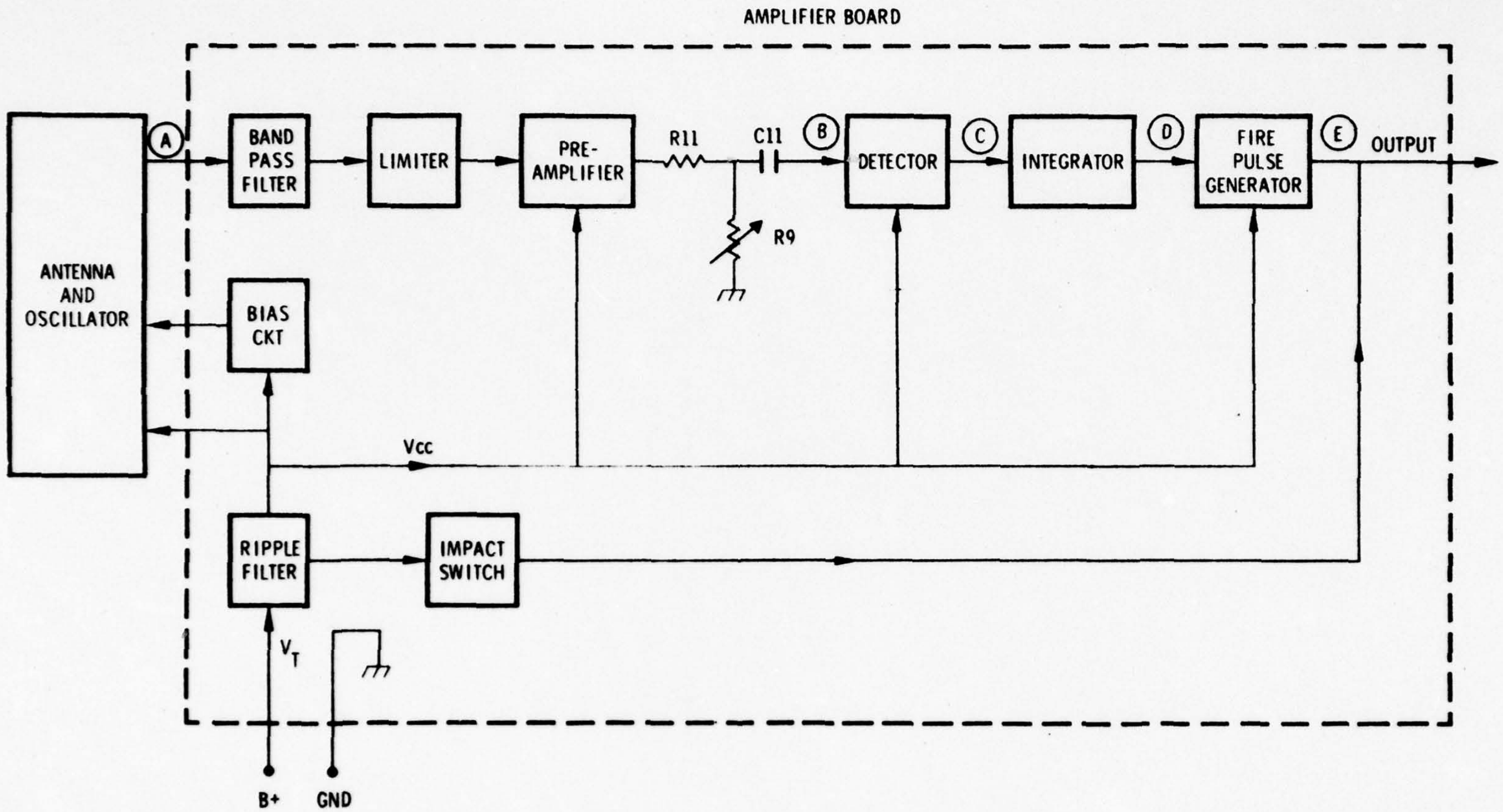


Figure A-3. Fuze Amplifier, Block Diagram

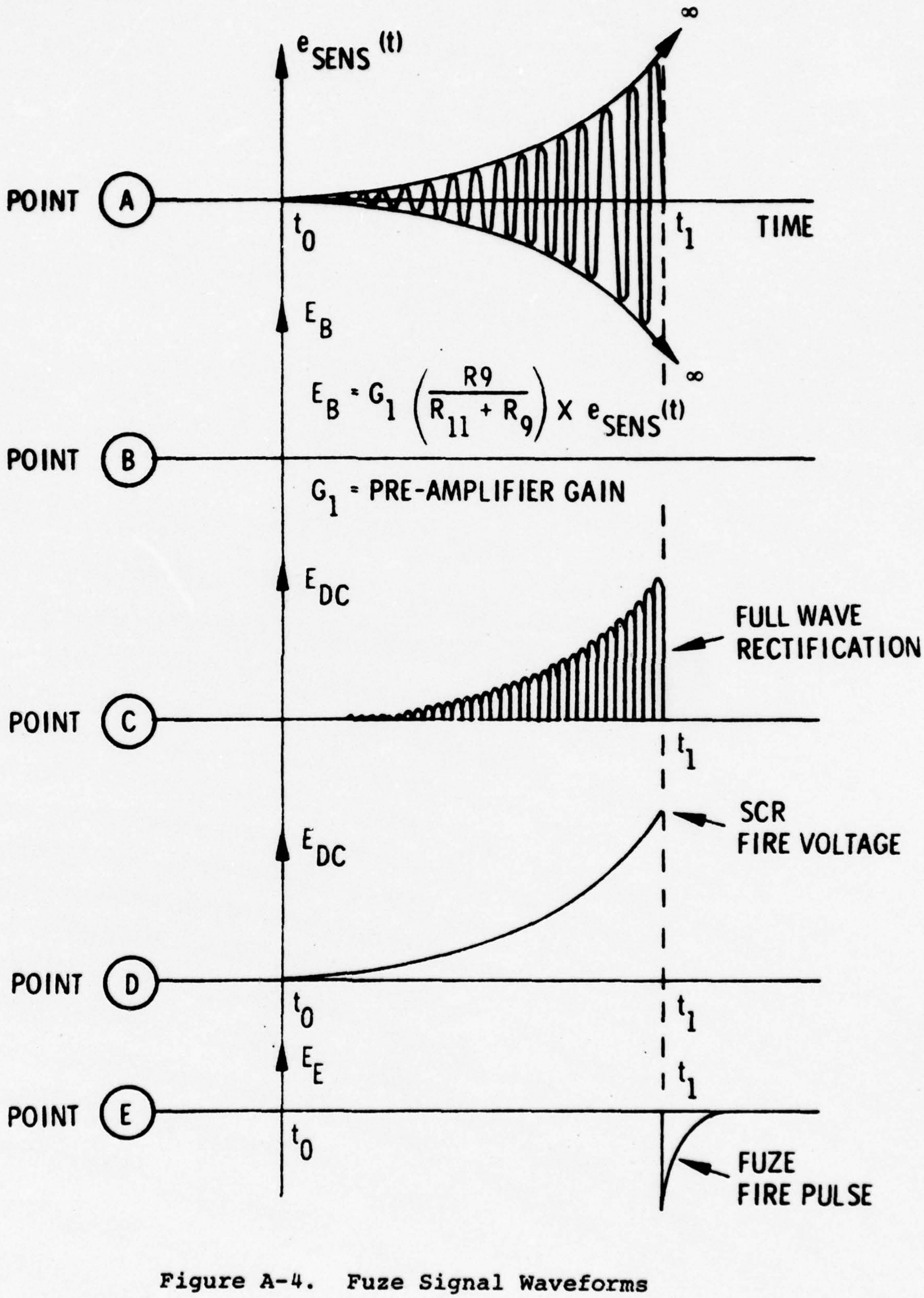


Figure A-4. Fuze Signal Waveforms

APPENDIX B

TRIMMABLE UNITS

TRIMMABLE CAPACITOR (OSCILLATOR SENSITIVITY ADJUSTMENT)

A *preliminary* design was made of a chip capacitor structure employing alumina as the dielectric and thick film gold as the counterelectrode material. The chip contains two capacitors, one of which will be trimmed in up to four incremental steps depending on whether the oscillator sensitivity must be adjusted up or down. The enlarged drawing of the capacitor layout (Figure B-1) shows that both capacitors share a common connection on the top surface where the segmented electrodes are located. This allows for a single ribbon connection to this surface while the counterelectrodes on the opposite side below the segments are soldered directly to the antenna assembly. The cross pattern is the laser beam starting position which becomes the 0,0 coordinate for programming of the cut. The total time to cut all four segments on the side with the start pattern, at one (1) inch per second cutting speed with 12 millisecond positioner inertial starting time, will be

$$\frac{120 \text{ mils}}{1000 \text{ mils/sec}} = 120 \text{ ms} + 12 \text{ ms} = 132 \text{ milliseconds}$$

maximum (if all 4 segments are removed)

If the capacitor on the other side must be trimmed, the positioner must be slewed to a point 25 mils past the last trimming link and 150 mils to the starting point on the other side at a slewing speed of 4 inches per second, this could add

$$\frac{(.120 + .025 + .150)\text{in}}{4 \text{ in./sec}} = \frac{195}{4} = 50 \text{ msec} + 48 \text{ msec (start time)}$$

or 98 milliseconds plus 132 milliseconds trim for a total of 230 milliseconds.

The photograph (Figure B-2) depicts a capacitor chip with leads ready for measurement (in production, only one lead would be required) along with a section of the present antenna configuration which allows for capacitor adjustment by normal soldering of a wire to a copper pad. The chip leads are gold plated copper ribbon soldered with low melting point indium alloy.

The chips are cut from an array of patterns printed on a 2 inch square alumina substrate as shown in Figure B-3. The dark lines observable on several patterns are trial laser cuts made at the laser manufacturers plants and are a result of the glass content of the ceramic. Experiments are in progress to evaluate substrate composition (99% vs 96%) thickness (.025" and .010") and surface finish (25 μinch and 5 μinch) as well as thick film gold compositions (fritted vs reactively bonded) with regard to electrical and trimming characteristics. A close up (30%) of the gold film cut by the laser at one (1) inch/second in multimode operation is shown in Figure B-4.

TRIMMABLE RESISTOR (AMPLIFIER GAIN ADJUSTMENT)

The amplifier shown in the photograph (Figure B-5) represents a machine insertable version of the amplifier board with a chip resistor with leads (of a design comparable to the one envisioned) in its approximate position if mounted on the top (component) side of the board. This arrangement would be compatible with the wave soldering of all components in a single operation. This arrangement, however would necessitate probing of the test points from the bottom of the board during trimming. If probing and trimming must be performed from the same side (namely the bottom, since one test point is inaccessible because of component location) the chip would have to be mounted separately on the bottom side as a secondary operation.

Fabrication of the resistor chip itself is portrayed in Figure B-6. The resistors are screened and fired in a matrix on a substrate, then cut apart. Lead attachment is then performed in the same fashion as for the chip capacitors. It is contemplated that several resistor compositions will be evaluated with regard to laser trimming and stability aspects.

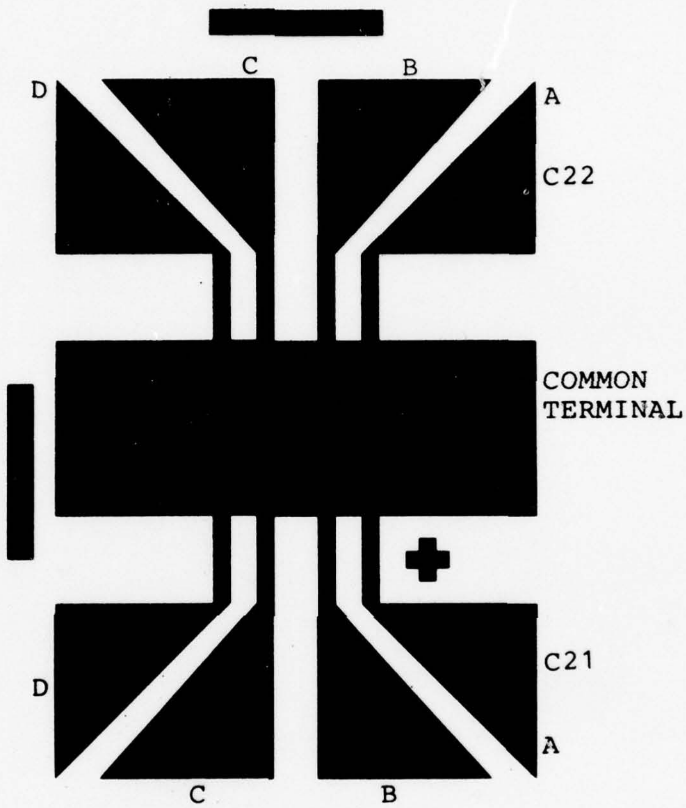


Figure B-1. Capacitor Layout, Enlarged Drawing

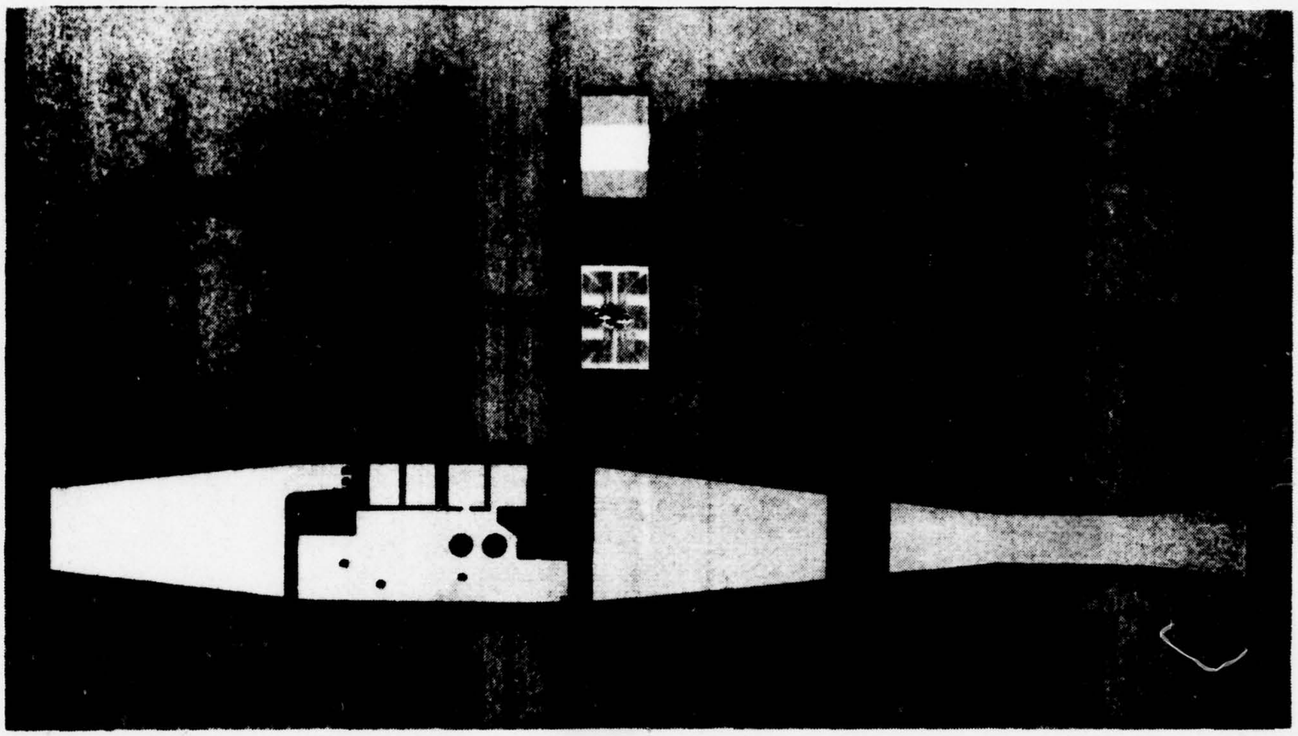


Figure B-2. Present Oscillator Capacitor Design and Proposed Capacitor Chip

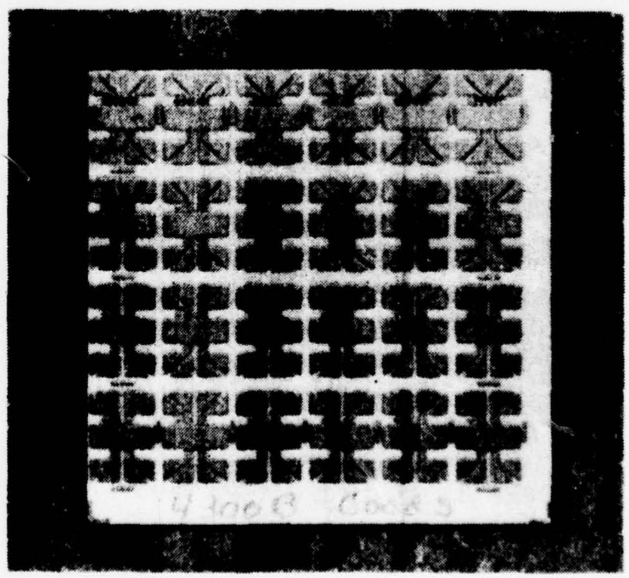


Figure B-3. Capacitor Array on 2-inch Square of Alumina

Figure B-4. Laser Cut; Gold Thick Film, Multimode (1 inch/sec, Transmitted Light)

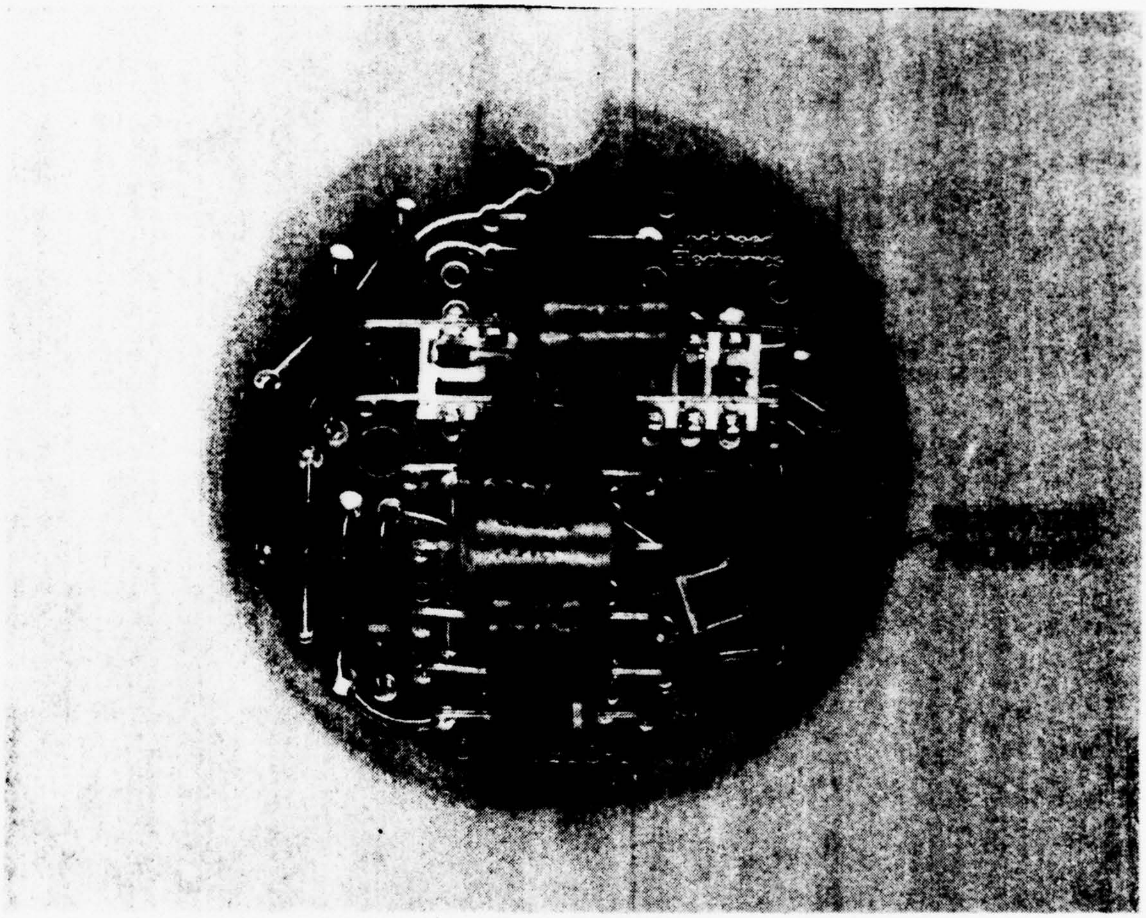


Figure B-5. Amplifier Board With Resistor Chip in Approximate Location

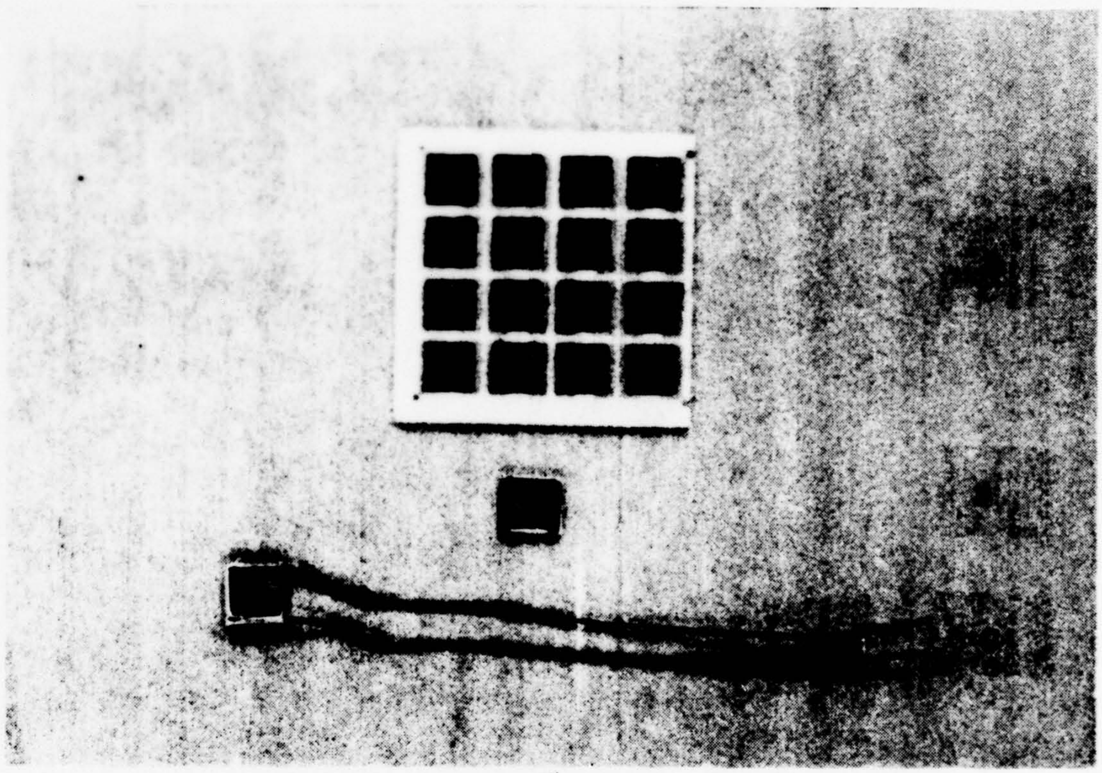


Figure B-6. Resistor Chip: A - Multiple Print and Fire Pattern; B - Single Diced Chip; C - Leaded Chip

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APPENDIX C

AMPLIFIER FILTER RESPONSE

The amplifier input filter and the filter following the detector have the same form (see Figure C-1). The impulse response and the step response can be easily derived by using the Laplace transform.

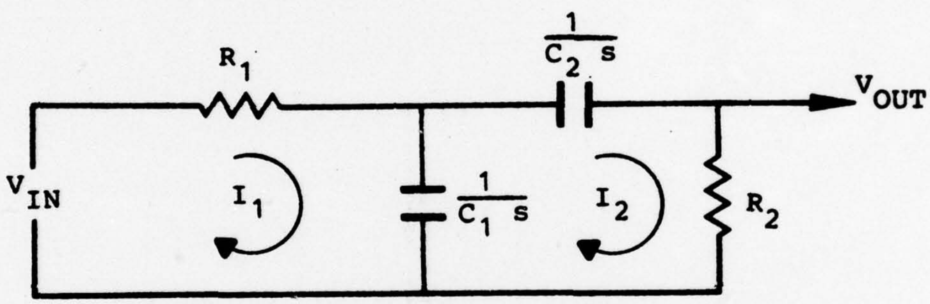

Figure C-1. Form of Amplifier Filters

Consider the loops formed by V_{in}, R_1, and C_1 and C1, C2, and R2. The voltage equations are as follows:

$$V_{in} = (R_1 + \frac{1}{C_1 s}) I_1 - \frac{1}{C_1 s} I_2 \text{ and} \quad (1)$$

$$0 = - \frac{1}{C_1 s} I_1 + (\frac{1}{C_1 s} + \frac{1}{C_2 s} + R_2) I_2, \quad (2)$$

where: s = complex frequency.

Multiplying Equation 2 by $(R_1 + \frac{1}{C_1 s})$, and dividing by $C_1 s$ gives:

$$0 = -\frac{1}{C_1 s} I_1 \quad (C_1 s)(R_1 + \frac{1}{C_1 s}) + (\frac{1}{C_1 s} + \frac{1}{C_2 s} + R_2) \ I_2$$

$$(C_1 s)(R_1 + \frac{1}{C_1 s}) . \qquad (3)$$

Adding Equations 1 and 3, and then dividing by I_2, yields:

$$\frac{V_{in}}{I_2} = (\frac{1}{C_1 s} + \frac{1}{C_2 s} + R_2)(C_1 s)(R_1 + \frac{1}{C_1 s}) - \frac{1}{C_1 s} . \qquad (4)$$

Using $V_{out} = R_2 I_2$, the result is:

$$\frac{V_{out}}{V_{in}} = \frac{R_2 I_2}{V_{in}} = \frac{R_2}{(\frac{1}{C_1 s} + \frac{1}{C_2 s} + R_2)(C_1 s)(R_1 + \frac{1}{C_1 s}) - \frac{1}{C_1 s}} . \qquad (5)$$

Let:

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} . \qquad (6)$$

Algebraic manipulation of Equation 5 gives:

$$F(s) = \frac{V_{out}}{V_{in}} = \frac{R_2}{\frac{R_2}{s} \ (s + \frac{1}{R_2 C})(C_1 s) \ \frac{R_1}{s} \ (s + \frac{1}{R_1 C_1}) - \frac{1}{C_1 s}}$$

$$F(s) = \frac{s}{\frac{1}{R_1 C_1} \ (s + \frac{1}{R_2 C})(s + \frac{1}{R_1 C_1}) - \frac{1}{R_2 C_1} \ \frac{1}{R_1 C_1}} . \qquad (7)$$

Let:

$$a_1 = \frac{1}{R_1C_1}, \tag{8}$$

$$a_2 = \frac{1}{R_2C}, \text{ and} \tag{9}$$

$$a_3 = \frac{1}{R_2C_1} . \tag{10}$$

Substituting in Equation 7 gives:

$$F(s) = a_1 s \frac{1}{(s + a_2)(s + a_1) - a_3a_1}$$

$$F(s) = a_1 s \frac{1}{s^2 + (a_1 + a_2) s + a_1a_2 - a_3a_1} \tag{11}$$

Solving for the poles in Equation 11 gives:

$$(p_1, p_2) = - \frac{(a_1 + a_2) \pm \sqrt{(a_1 + a_2)^2 - 4(a_1a_2 - a_3a_1)}}{2}$$

$$= - \frac{(a_1 + a_2) \pm \sqrt{(a_1 - a_2)^2 + 4a_3a_1}}{2} . \tag{12}$$

Rewriting Equation 10 in terms of the poles gives:

$$F(s) = a_1 \frac{s}{(s - p_1)(s - p_2)} \tag{13}$$

$$F(s) = \frac{a_1}{p_2 - p_1} \quad - \frac{p_1}{(s - p_1)} + \frac{p_2}{(s - p_2)} . \tag{14}$$

Taking the inverse Laplace transform of Equation 14 gives the impulse response:

$$h(t) = \frac{a_1}{p_2 - p_1} (- p_1 e^{p_1 t} + p_2 e^{p_2 t}), \tag{15}$$

which can be written as:

$$h(t) = A e^{p_1 t} + B e^{p_2 t}, \tag{16}$$

where: $$A = \frac{-a_1}{p_2 - p_1} p_1 \text{ and} \tag{17}$$

$$B = \frac{a_1}{p_2 - p_1} p_2 . \tag{18}$$

The integral of the impulse response is the step response. Integrating Equation 15 gives:

$$g(t) = \int_o^t h(t)\, dt \tag{19}$$

$$= \int_o^t \frac{a_1}{p_2 - p_1} [- p_1 e^{p_1 t} + p_2 e^{p_2 t}]$$

$$= \frac{a_1}{p_2 - p_1} [-e^{p_1 t} + e^{p_2 t}], \tag{20}$$

which can be written as:

$$g(t) = C e^{p_1 t} + D e^{p_2 t}, \tag{21}$$

$$\text{where:} \quad C = -\frac{a_1}{p_2 - p_1} \text{ and} \tag{22}$$

$$D = \frac{a_1}{p_2 - p_1} . \tag{23}$$

Substituting the specific values of the components of the input filter into Equations 6, 8, 9, 10, 12, 17, 18, 22, and 23 gives:

$$\begin{aligned} p_1 &= -1,469 \text{ rad/sec,} \\ p_2 &= -24,133 \text{ rad/sec,} \\ A &= -1,379 \text{ volts,} \\ B &= 22,656 \text{ volts,} \\ C &= 0.94 \text{ volts, and} \\ D &= -0.94 \text{ volts.} \end{aligned} \tag{24}$$

Similarly, using the component values of the filter after the detector gives:

$$\begin{aligned} p_1 &= -48.0 \text{ rad/sec,} \\ p_2 &= -9.2 \text{ rad/sec,} \\ A &= 26.9 \text{ volts,} \\ B &= -5.15 \text{ volts,} \\ C &= -0.56 \text{ volts, and} \\ D &= 0.56 \text{ volts.} \end{aligned}$$

APPENDIX D

FREQUENCY CONTENT OF TCHEBYCHEFF WEIGHTED PULSES

A computer analysis of the frequency content of a 0.1-second weighted pulse was performed by sampling the pulse at a rate of 160 Hz (see Figure D-1). The frequency content was calculated by using the formula for the Discrete Fourier Transform (DFT), namely:

$$DFT(f) = \sum_{n=0}^{15} f(nT)e^{-j2\pi fnT} \qquad (1)$$

The frequency, f, was varied in 2-Hz increments up to 78 Hz, which is about half the sampling rate. The magnitude, at each frequency, was found by taking the square root of the sum of the squares of the real and imaginary parts.

Five different Tchebycheff weighting factors were used, as follows:

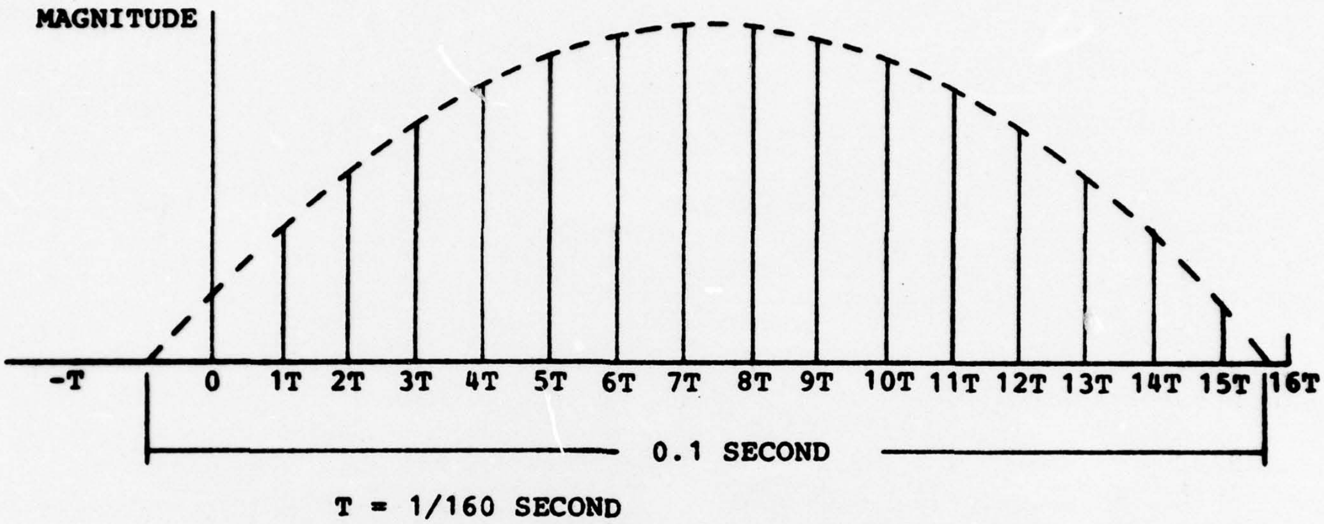

Figure D-1. Sample Weighted Pulse

Tchebycheff Weighting Factors

	Constant	40 dB	50 dB	60 dB	70 dB
0T	1.0000	1.1376	0.4987	0.2408	0.1266
1T	1.0000	1.9636	1.2289	0.7891	0.5237
2T	1.0000	3.3195	2.4400	0.8235	1.3904
3T	1.0000	4.9260	4.0573	3.3758	2.8432
4T	1.0000	6.6131	5.9124	5.3164	4.8131
5T	1.0000	8.1634	7.7299	7.3397	6.9921
6T	1.0000	9.3534	9.1876	9.0327	8.8901
7T	1.0000	10.0000	10.0000	10.0000	10.0000
8T	1.0000	10.0000	10.0000	10.0000	10.0000
9T	1.0000	9.3534	9.1876	9.0327	8.8901
10T	1.0000	8.1634	7.7299	7.3397	6.9921
11T	1.0000	6.6131	5.9124	5.3164	4.8131
12T	1.0000	4.9260	4.0573	3.3758	2.8432
13T	1.0000	3.3195	2.4400	0.8235	1.3904
14T	1.0000	1.9636	1.2289	0.7891	0.5237
15T	1.0000	1.1376	0.4987	0.2408	0.1266

Tables D-1 through D-5 show the results, as a function of frequency vs pulse magnitude, for the different weighting factors. It should be noted that in Table D-2 the magnitude falls below 40 dB at 20 Hz, and remains below 40 dB at all higher frequencies. When this pulse is used as the amplitude modulation of a 720-Hz carrier, the bandwidth will be twice 20 Hz (i.e., 40 Hz). It is emphasized that this is the 40-dB bandwidth rather than the usual 3-dB bandwidth.

Table D-1. Frequency vs DFT Pulse Magnitude With Constant Weighting

Frequency (Hz)	Magnitude (dB)
0.0	16.0000
2.0	14.9717
4.0	12.1217
6.0	8.0915
8.0	3.7574
10.0	0.0000
12.0	2.5179
14.0	3.5037
16.0	3.0777
18.0	1.6982
20.0	0.0000
22.0	1.4040
24.0	2.0949
26.0	1.9464
28.0	1.1250
30.0	0.0000
32.0	1.0000
34.0	1.5362
36.0	1.4644
38.0	0.8659
40.0	0.0000
42.0	0.8004
44.0	1.2507
46.0	1.2110
48.0	0.7265
50.0	0.0000
52.0	0.6894
54.0	1.0900
56.0	1.0674
58.0	0.6472
60.0	0.0000
62.0	0.6265
64.0	1.0000
66.0	0.9882
68.0	0.6045
70.0	0.0000
72.0	0.5951
74.0	0.9577
76.0	0.9540
78.0	0.5882

Table D-2. Frequency vs DFT Pulse Magnitude With 40-dB Weighting

Frequency (Hz)	Magnitude (dB)
0.0	90.9532
2.0	87.8949
4.0	79.2153
6.0	66.2914
8.0	51.0819
10.0	35.7135
12.0	22.0570
14.0	11.3943
16.0	4.2503
18.0	0.4153
20.0	0.8688
22.0	0.6229
24.0	0.1674
26.0	0.7819
28.0	0.8791
30.0	0.4780
32.0	0.1616
34.0	0.7073
36.0	0.9094
38.0	0.6942
40.0	0.1742
42.0	0.4158
44.0	0.8248
46.0	0.8873
48.0	0.5852
50.0	0.0473
52.0	0.5071
54.0	0.8577
56.0	0.8688
58.0	0.5394
60.0	0.0008
62.0	0.5371
64.0	0.8668
66.0	0.8629
68.0	0.5285
70.0	0.0074
72.0	0.5401
74.0	0.8668
76.0	0.8640
78.0	0.5331

Table D-3. Frequency vs DFT Pulse Magnitude
With 50-dB Weighting

Frequency (Hz)	Magnitude (dB)
0.0	82.1096
2.0	79.7945
4.0	73.1767
6.0	63.1734
8.0	51.1112
10.0	38.4740
12.0	26.6360
14.0	16.6406
16.0	9.0681
18.0	4.0135
20.0	1.1662
22.0	0.0400
24.0	0.2520
26.0	0.0426
28.0	0.1905
30.0	0.2570
32.0	0.1442
34.0	0.0533
36.0	0.2146
38.0	0.2568
40.0	0.1669
42.0	0.0037
44.0	0.1703
46.0	0.2563
48.0	0.2254
50.0	0.0947
52.0	0.0765
54.0	0.2138
56.0	0.2594
58.0	0.1958
60.0	0.0508
62.0	0.1146
64.0	0.2324
66.0	0.2547
68.0	0.1734
70.0	0.0219
72.0	0.1383
74.0	0.2426
76.0	0.2493
78.0	0.1559

Table D-4. Frequency vs DFT Pulse Magnitude With 60-dB Weighting

Frequency (Hz)	Magnitude (dB)
0.0	73.8360
2.0	72.1631
4.0	67.3451
6.0	59.9472
8.0	50.7988
10.0	40.8496
12.0	31.0175
14.0	22.0570
16.0	14.4747
18.0	8.5033
20.0	4.1309
22.0	1.1706
24.0	0.6537
26.0	1.6280
28.0	1.9936
30.0	1.9258
32.0	1.5420
34.0	0.9282
36.0	0.1697
38.0	0.6286
40.0	1.3407
42.0	1.8360
44.0	2.0083
46.0	1.8059
48.0	1.2513
50.0	0.4430
52.0	0.4622
54.0	1.2833
56.0	1.8556
58.0	2.0665
60.0	1.8794
62.0	1.3389
64.0	0.5575
66.0	0.3107
68.0	1.10[illegible]6
70.0	1.67[illegible]5
72.0	1.9406
74.0	1.8558
76.0	1.4470
78.0	0.7904

Table D-5. Frequency vs DFT Pulse Magnitude
With 70-DB Weighting

Frequency (Hz)	Magnitude (dB)
0.0	71.1584
2.0	69.6065
4.0	65.1288
6.0	58.2293
8.0	49.6546
10.0	40.2731
12.0	30.9436
14.0	22.3957
16.0	15.1455
18.0	9.4574
20.0	5.3538
22.0	2.6648
24.0	1.1000
26.0	0.3261
28.0	0.0330
30.0	0.0225
32.0	0.0003
34.0	0.0211
36.0	0.0172
38.0	0.0021
40.0	0.0190
42.0	0.0217
44.0	0.0101
46.0	0.0074
48.0	0.0200
50.0	0.0209
52.0	0.0102
54.0	0.0060
56.0	0.0191
58.0	0.0226
60.0	0.0149
62.0	0.0001
64.0	0.0146
66.0	0.0223
68.0	0.0193
70.0	0.0074
72.0	0.0080
74.0	0.0196
76.0	0.0221
78.0	0.0143

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Production Measurement of Fuze Components Under Dynamic Stress		5. TYPE OF REPORT & PERIOD COVERED First Quarterly Progress Report 11 May - 10 Aug 1976
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) A.J. Eisenberger P. Kaszerman		8. CONTRACT OR GRANT NUMBER(s) DAAB07-76-C-0032 New
9. PERFORMING ORGANIZATION NAME AND ADDRESS Lockheed Electronics Co., Inc. U.S. Highway 22 Plainfield, N.J. 07061		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 275966
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Army U.S. Army Electronics Command Ft. Monmouth, N.J. 07703		12. REPORT DATE 9 September 1976
		13. NUMBER OF PAGES 68
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Prod and Proc Directorate DRSER-PRI-P1-1		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Laser Trim
Computer Test
Functional Test

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Work has been started to develop a dynamic test and correction system for electronic assemblies, capable of high speed operation. The system will be verified by testing and trimming 6000 M732 fuze components. A third generation test station has been designed. It will include a laser trimmer. Analysis of the fuze components and the test stimuli has been completed. A simulation of the entire system has been initiated. All electrical components for the fuze assemblies have been released.

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